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THE PARASITIC ORIGIN OF MACROËRGATES AMONG ANTS.[1]

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THE genus Pheidole among ants is in several respects noteworthy. The unusually large number of species which it comprises afford valuable materials for the taxonomist, while their wide distribution and geographical variation cannot fail to be of interest to the ecologist. Of even greater interest are the certainly very diverse but still imperfectly known habits of the species of this extensive genus. And, finally, a fascinating congeries of morphological and physiological problems centers about the striking dimorphism of the sterile females, or workers of these ants.

In all the known species of Pheidole the worker phase is represented by two very different forms: small-bodied, small-headed, active workers proper, and larger, big-headed, sluggish soldiers. The latter are often of monstrous aspect, and their rôle in the social economy of the various species is still to be worked out in detail.

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 22.

Until very recently the genus has been characterized as presenting no forms intermediate between the workers and soldiers, in contradistinction to the Old World genus Pheidologeton, the species of which exhibit even in the same colony numerous intermediates between the gigantic, big-headed soldiers and the minute workers. During the past year I found that two of our Texan and Mexican species of Pheidole (*Ph. kingii* André, *var. instabilis* Emery, and *Ph. vaslitii* Pergande) resemble Pheidologeton in presenting, in the very same nest, complete series of intermediates.[1] My attention was directed to this singular condition by Professor Emery, who has described the Texan *Ph. instabilis* from specimens collected at Austin. He has also rectified the synonomy of the Mexican *Ph. tepicana* Pergande, which presents a like polymorphism and has therefore led to the description of several species from soldiers of different dimensions.[2] Recently Professor Forel, utilizing some observations which I made at Queretaro, Mexico, has been able to rectify a similar error in the synonymy of *Ph. vaslitii* Pergande.[3]

In the present paper I desire to call attention to another peculiar modification of the workers of Pheidole, traceable to a perfectly definite, though obviously very different cause from that which must bring about the above-mentioned di- and polymorphism. June 3, 1901, I found at New Braunfels, Texas, on a shady hill that slopes to the lovely sources of the Comal River, two medium-sized nests of *Ph. commutata* Mayr. They were under stones about sixty feet apart. One contained ants of the typical dark variety of the species, while in the other nest both workers and soldiers were decidedly paler. In either case on lifting the stone my attention was attracted by several very large and conspicuous workers with huge abdomens, moving about among the workers and soldiers of normal dimensions. I had been collecting and observing the

[1] Wheeler, W. M. Notices Biologiques sur les Fourmis Mexicaines, *Ann. Soc. Entomol. de Belgique*, tome xlv (1901), pp. 199–205.

[2] Emery, C. Remarques sur un Petit Groupe de Pheidole de la Région Sonorienne, *Bull. Soc. Entomol. de France* (année 1901), No. 5, pp. 119–121.

[3] Forel, A. Fourmis Mexicaines récoltées par M. le prof. W. M. Wheeler, *Ann. Soc. Entomol. de Belgique*, tome xlv (1901), pp. 123–141.

little fungus-growing ants, *Cyphomyrmex rimosus* Spinola, which abounded on the same hill-slope, and all my bottles and bags used for living colonies were filled with these remarkable ants. I was therefore compelled to preserve in some small vials of alcohol as many of the Pheidole workers as could be captured. At the time I supposed that the huge individuals might represent some hitherto unknown guest-ant which had taken up its abode in the nests of the Pheidole.

On returning from my collecting trip I found that the conspicuous individuals were nothing more nor less than gigantic workers of *Ph. commutata*. One of the nests had yielded six, the other three, of these creatures. There were besides from each nest two or three somewhat smaller individuals clearly intermediate in size between the typical and the gigantic workers. All of these large individuals are evidently to be regarded as belonging to Wasmann's category of macroërgates,[1] since they are certainly "individuals which approach the females in an abnormal manner only in the size of the body, but in other respects (even in the development of the abdomen) are normal workers." Although the abdomen is enormously distended in the macroërgates of *Ph. commutata*, it is nevertheless clearly of the worker type.

The length of the normal workers of the Texan *Ph. commutata* is not greater than 3 mm. Many of them are scarcely more than 2.5 to 2.8 mm., which was the length of Mayr's type specimens from Florida.[2] The largest macroërgates, however, measure 5 mm., while the smaller ones are fully 4 to 4.5 mm. long. Thus the volumes of the normal workers and the extreme macroërgates would be in the ratio of 27 to 225 if they had the same form. But the abdomens of the latter are so enormously distended that the ratio must be 27 to at least 200. In other words, the large macroërgates are nearly eight times as large as the normal workers. They are even larger than the soldiers, which measure about 4 mm., though in this

[1] Wasmann, E. Die ergatogynen Formen bei den Ameisen und ihre Erklärung, *Biol. Centralbl.*, Bd. xv (1895), Nr. 16 u. 17, pp. 606–646.

[2] Mayr, G. Die Formiciden der Vereinigten Staaten von Nordamerika, *Verh. d. Zool.-Bot. Ges.*, Bd. xxxvi (Wien, 1886), pp. 419–464.

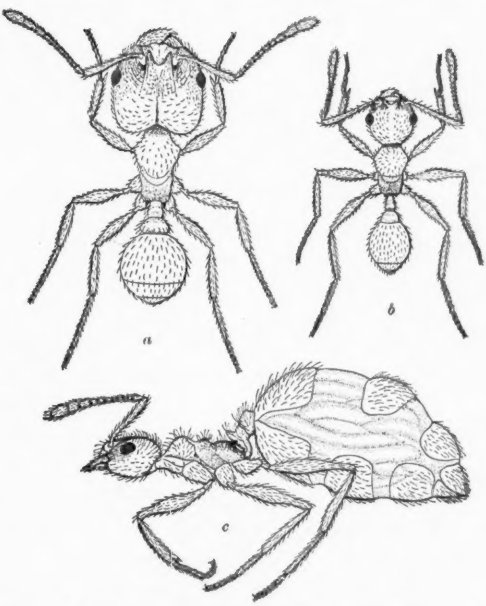
case the difference in size is not so striking on account of the enormous heads of the latter. The size relations are shown in the figures, which represent the soldier, normal and macroërgatic workers, drawn with the camera lucida under the same magnification.

Examination even with a good pocket lens reveals the cause of the great abdominal development of the macroërgates. One sees distinctly the white coils of a parasitic worm distending the abdomen till its dorsal and ventral sclerites are widely separated by the tense intersegmental membranes. Thus the abdomen of the Pheidole comes to resemble externally that of replete individuals of the honey ant (*Myrmecocystus melliger*) or our common northern *Prenolepis imparis.* In some of the alcoholic specimens the tense abdominal wall has burst and allowed a few of the coils of the parasite to protrude. Such specimens may perhaps suggest the way in which the parasite ultimately effects its escape from the ant, if indeed it ever leaves its host.

My friend, Dr. T. H. Montgomery, who has kindly examined a few of the Pheidoles, writes me that the parasite is a species of Mermis. Its exact location in the ant's body is not easy to determine, *i.e.*, whether it occupies the lumen of the enormously distended crop, or ingluvies, or lies in the body cavity outside of the alimentary tract. From careful dissection of a single large macroërgate — the one represented in the figure — I conclude that the Mermis lies *within* the ingluvies. In this case the head of the parasite extended forward through the postpetiolar and into the petiolar segment, thus occupying the attenuated neck of the ingluvies. The fat-body in the parasitized ants is almost or completely absent and the walls of the enormously distended crop are practically in contact with the walls of the abdomen. The large macroërgate figured contained only a single closely convoluted Mermis, which was fully 50 mm. long, or ten times the length of the ant. One individual dissected by Dr. Montgomery contained two somewhat smaller parasites, together with many of their eggs. According to Dr. Montgomery, the parasites are "either fully mature or

in what von Linstow calls the 'second larval stage,' which is, however, really the immature stage."[1]

While it is certainly somewhat singular that a species of Mermis should occur in ants, even greater interest attaches to the case under discussion on account of the manifest effects of the parasite on its host. The fact that all the infested individuals are of huge size as compared with the normal



Pheidole commutata Mayr. *a*, normal soldier; *b*, normal worker; *c*, parasitized macroërgate. (Drawn under the same magnification.)

workers is remarkable, for, on first thought, one would certainly expect an animal infested with such a large parasite to be stunted or, at any rate, below the average stature of the species. This paradoxical condition of the macroërgatic Pheidoles is easily understood, however, when we make due allowance for certain peculiarities in the behavior of ants. In the first place it is obvious that the parasites must enter the body

[1] Von Linstow, O. Das Genus Mermis, *Archiv. f. mikr. Anat.*, Bd. liii (1898).

of the worker ant while she is still a larva. This is proved by the fact that two of the large macroërgates are callows, one of them still very soft and pale yellow, the other — again the one represented in the figure — with harder integument, but without the deep coloration of the mature workers. Such huge parasites could scarcely have made their appearance in ants so recently escaped from their pupæ. But even if there had been no callows among the macroërgates, the truth of the above statement would still be patent, both because the macroërgates were all infested while none of the normal workers were found to contain parasites, and because the stature of an ant is, of course, fixed in the pupal stage and cannot be subsequently increased to the dimensions exhibited in the cases under consideration.

It is evident, furthermore, that the macroërgatic stature, which is very apparent not only in the distention of the abdomen but also in the greater dimensions of the head, thorax, petiole, antennæ, and legs, can have its origin only in an unusually large amount of food consumed during the growth period of larval life.[1] Now, as I have shown in former papers,[2] different species of ants employ very different methods of feeding their larvæ. Species of Camponotus, Formica, Lasius, and Myrmica feed their larvæ with liquid food regurgitated from their crops, and possibly also with the secretion of the salivary glands. Other species, however, like the Ponerinæ and some Myrmicinæ (Aphænogaster, Pogonomyrmex, Tomognathus, and some species of Pheidole), feed their larvæ with comminuted insects. Unfortunately I have not been able to observe the method of feeding in *Ph. commutata*, but it is safe to say that it must conform to one or both of these methods. If the larvæ are fed by regurgitation, we must suppose that the parasitized

[1] The opposite condition, *i.e.*, a small amount of food consumed during larval life, results in what may be called *microërgatic* forms. Such are the firstborn workers of all incipient ant colonies. These forms are, of course, perfectly *normal* products of underfeeding, whereas the macroërgates of Pheidole are products of overfeeding induced by a *pathological* condition.

[2] Wheeler, W. M. A Study of Some Texan Ponerinæ, *Biol. Bull.*, vol. ii (1900), No. 1, pp. 1–31, Figs. 1–10; and The Habits of Ponera and Stigmatomma, *Biol. Bull.*, vol. ii (1900), No. 2, pp. 43–69, Figs. 1–5.

individuals have some means of informing their nurses that their appetite is unusually keen — like that of a human being infested with a tapeworm. If, on the other hand, the larvæ are fed with comminuted insects, they could simply of their own accord eat much more food than is consumed by the larvæ of normal workers. In either case, however, *the stimulus to the increased feeding that finally results in the macroërgatic stature must, of course, reside in the larva and not in the worker ants which supply the food.*

The ability of a small animal like the worker of *Ph. commutata* to nourish a parasite larger than the normal individuals of the host species is accounted for by the fact that the larvæ and adults of these social insects are so readily fed by other members of the colony. The infested ant therefore suffers relatively little inconvenience when compared with an animal which must rely entirely on its own efforts in securing food. Both during the larval and adult stages the macroërgate must be fed by the other ants, for it is extremely doubtful whether these heavy-bodied individuals ever leave the nest for the purpose of foraging. They probably remain at home like the heavy-headed soldiers.

It is not difficult to understand how the Pheidole larvæ become infested with the Mermis, since the parasite extrudes its eggs within the crop of the adult worker. Such eggs or the embryos arising from them could easily find their way into the gullet and mouth of the ant and be transferred thence to the larvæ while the latter are being licked and cleansed; or, in case the workers of *Ph. commutata* feed their larvæ by regurgitation, the transferring of the parasite would be still easier and more direct.

Other interesting conclusions follow from a consideration of the fact that all the macroërgates are structurally of the pure worker type. Except in the excessive size and peculiar hypertrophy of the abdomen, I can detect no morphological differences between the parasitized individuals and their diminutive sister ants. There is certainly no appreciable tendency to approach the soldier or female type of structure. From this we may conclude either that the larvæ must become infested with

the Mermis after they have developed as workers so far that their structure can no longer be affected except in volume, or that the still undifferentiated larvæ are infested but nevertheless develop into workers because so much of the food which they devour is appropriated by their parasites. A decision between these alternatives would require more precise study than was possible under the circumstances.

While there can be no doubt that macroërgatism in *Ph. commutata* is due to the presence of the Mermis, we cannot with certainty exclude the possibility of an atavistic tendency towards macroërgatism in the workers of this genus; for, as Emery has shown in a very suggestive paper,[1] in those ants which have the sterile females represented by huge soldiers and diminutive workers, the latter have without doubt undergone a reduction in size during phylogenetic development. It would be possible, therefore, to explain macroërgatism as an attempt to regain the ancestral worker stature which was, of course, that of the queen. This is probably the explanation of macroërgatism in many ants, *e.g.*, in Solenopsis, and possibly also in the small group of Pheidole mentioned in the introduction to this paper. While a similar reversional tendency may also be present in *Ph. commutata*, it is perhaps unnecessary to lay much stress upon it, since the presence of the Mermis is of itself quite sufficient to account for the stature of the macroërgates.

It is interesting in conclusion to compare the production of macroërgates in the nests of *Ph. commutata* with certain phenomena observed by Wasmann[2] in mixed nests of *Polyergus rufescens* and *Formica fusca.* He finds that such nests are peculiarly liable to contain ergatoid females of the former species, *i.e.*, "individuals which in size and in the development of the abdomen (even of the ovaries) belong to the true female type, but have the thoracic structure of the workers and are therefore wingless." From a biological point of view these are, as Wasmann claims, really secondary queens. He believes that they are produced by the slave ants (*F. fusca*) through

[1] Die Entstehung und Ausbildung des Arbeiterstandes bei den Ameisen, *Biol. Centralbl.*, Bd. xiv (1894), pp. 53–59.

[2] *Loc. cit.*

excessive care and feeding of certain larvæ which had previously been permitted to develop as workers beyond the stage in which the wing rudiments would make their appearance in queen larvæ. In other words, the *fusca* workers attempt to change worker larvæ of Polyergus into queens but succeed only in producing the wingless ergatoids. In explanation of such conduct, Wasmann suggests that the *F. fusca* usually have several queens even in very small nests and may perhaps retain the instinct, when enslaved by Polyergus, to educate numerous female ants. If, after the nuptial flight of the Polyergus, they find no fertile queens of their own species in the nest they may endeavor to transform the young worker larvæ into queens with the above-mentioned result. Wasmann's hypothesis is of interest, as it points to the existence of a peculiar instinct in ants which regulates the number and character of the personnel in the colony. We know that such an instinct is well developed in termites, and it is more than probable that it exists also among ants. It offers an interesting field for future investigation.

Both Wasmann's hypothesis to account for the ergatoid females of Polyergus by excessive feeding of the worker larvæ, and his interesting "Lomechusa-Hemmungs-Hypothese," in which he accounts for the pseudogynes of Formica through an attempt on the part of the ants to transform queen larvæ into workers, seem to start from the assumption that the larvæ are quite passive and that the worker ants feed them entirely in obedience to certain instinctive promptings of their own. This accords with Emery's view [1] that the sexual polymorphism of the ant colony is the result of the development of an instinct in the workers to feed the larvæ in different ways. Hence, "the characters in which the worker differs from the corresponding sexual form are not congenital, or blastogenous, but acquired, *i.e.*, somatogenous. Nor are these characters transmitted by heredity, except as a peculiarity of the germplasma to enter on different paths of ontogenetic development according to the different circumstances of existence." While this view is undoubtedly supported by many facts, and while

[1] *Loc. cit.*

considerable importance may indeed be attributed to the initiative of the workers in determining the character of the adult ants which they rear, the macroërgates of *Ph. commutata* prove, nevertheless, that we must also attribute a certain amount of initiative to the larvæ themselves. If this be granted, it is but a short step to the admission that the initiative of the larva, even under normal circumstances, — *i.e.*, when not infested with internal parasites, — may be considerable. It is not altogether improbable that further investigation with this possibility in mind may lead to some alteration or emendation of the various hypotheses that have been framed for the purpose of explaining the complicated phenomena of sexual polymorphism. Thus we may find eventually that the tendency to develop abortive ovaries is really inherited (through the fertile queens of course), and that differences in the chemical nature of the internal secretions, perhaps analogous to those which are supposed to obtain between castrated and non-castrated animals, may furnish the different stimuli that induce the larvæ to demand of their own accord more or less food, or food of a different quality, and to develop accordingly into queens or workers.

COLEBROOK, CONN., August 10, 1901.

ON SOME POINTS IN THE ANATOMY OF A COLLECTION OF AXOLOTLS FROM COLORADO, AND A SPECIMEN FROM NORTH DAKOTA.

HENRY LESLIE OSBORN.

I. The Collection from Colorado.

In a previous article in this journal by the writer ('00) reference was made to a collection of axolotls which were kindly loaned by Dr. Lee for comparison with the specimen from Amenia, North Dakota, therein described. By an unfortunate mistake these specimens were located from Montana, but in fact they are from Colorado. The material was collected by Dr. Thomas G. Lee, of the University of Minnesota, during a brief stay in the mining town of Crede, in southern Colorado, during the latter part of August and the beginning of September, 1896. Having heard mention among the people there of "dogfish" and "fish with legs on 'em," he succeeded in locating the wonders in a lake twenty-five miles distant and paid the place a visit. He found the lake occupying a narrow valley hemmed in between two mountain ridges and dammed back by a natural formation, apparently of glacial origin, giving it much the appearance of an artificial lake. The elevation of the place is about eight thousand feet above the level of the sea. The water is very cold. The lake appeared to be very deep. At a distance of about a hundred feet from the shore a line one hundred feet in length would not reach the bottom. There were water plants growing abundantly in the lake, and among them there were areas that were free and open, in which the axolotls were seen coming up from time to time apparently to breathe. They were then captured with a dip-net. The larger sized ones were found farther out, while smaller ones were reached from the shore. Dr. Lee informs me further that he

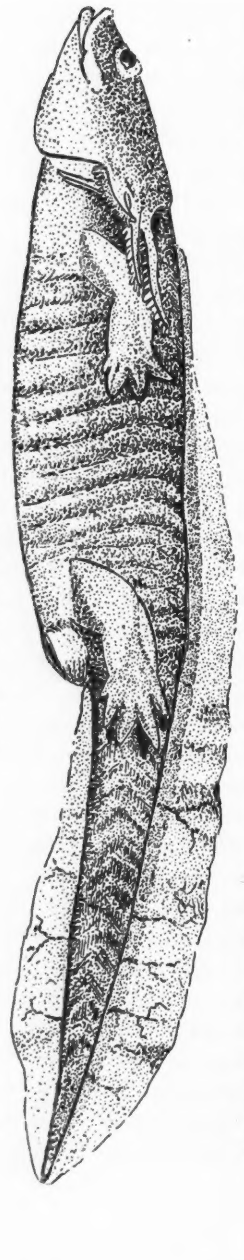


FIG. 1.—Side view of siredon from Colorado.

found the ordinary larvæ of *Amblystoma tigrinum* ranging in length from one to four inches in the irrigation ditches that were common in the San Luis valley in the vicinity of Garrison.

The material was preserved in 5% formalin. It contains in all twenty-six specimens, with the following lengths in millimeters, *viz.*: 89, 92, 98, 100, 103, 105, 105, 105, 106, 109, 110, 112, 113, 113, 115, 118, 118, 120, 121, 160, 190, 215, 220, 250, 250, 262.

Most of the specimens only corroborate the descriptions of previous writers as to the external characteristics of these interesting forms, and are mentioned here chiefly for the sake of making a record of the facts and the locality. One of them is in an advanced stage of metamorphosis, and has nearly reached the terrestrial form of *Amblystoma tigrinum*. This specimen is of especial interest, because it is in the act of undergoing its development in the midst of its natural surroundings. Marsh and Tegetmeier, as well as others, have described the metamorphosis of siredons under artificial conditions, but I do not know of an account of a siredon transforming in its natural environment. A number of measurements of these specimens were made, and are given in a table of measurements at the end of this article.

The external characteristics are indicated in Fig. 1, which is drawn from specimen No. 2 of the following lists. In the account which now follows, the siredon described as the type of the collection is No. 2. It will be compared with the other siredons, with No. 10, a metamorphosing specimen, and with adult specimens of *Amblystoma tigrinum* from the collection in the museum of Hamline University, from St. Paul, Minn.

The coloration (of the formalin material) is uniform and not mottled or spotted. The head and trunk are dark above and light beneath, the division line running from the jaw along the side of the head and on the body on the level of the ventral borders of the limbs. The post-abdomen, or "tail," is dark throughout, as are also the dorsal and ventral folds of skin, "fins." One of the larger specimens (No. 8) differs from the rest in being distinctly spotted. The spots are very numerous and small, about 1 mm. across, and are found in all parts of the dark area of the animal. Both of the Dakota specimens are spotted, as can be seen by a reference to Fig. 7 of this article and Fig. 1 of the preceding. In both of these, however, the spots are fewer and larger and more distinct. Baird's *S. gracilis* ('59 Vol. X, Pl. XLIV) is also spotted, and the Colorado specimen is more like to it, according to the illustration, than to the Dakota forms. In the smaller specimens of the Colorado collection the dorsal darker area is not uniform in tone, but is mottled with dark irregular patches scattered irregularly upon it. These patches are not distinctly bounded, but shade into the general color tone at the edges, and are very irregular in shape. They also extend out upon the dorsal and ventral fins.

The head in the Colorado specimens differs markedly from that of terrestrial amblystomas in several particulars. In order to afford the opportunity to test some of these points, I give a number of measurements made on specimens of Amblystoma found at Hamline, Minnesota. I may say that these are fully metamorphosed and strictly terrestrial.

By dividing the length of the head, from the snout to the fold crossing between the bases of the hinder gills, by the length from the chin to the posterior boundary of the cloacal

opening, we obtain the ratio of head length to head and body length, and can then make direct comparisons, irrespective of difference of length. By measuring to the cloaca we avoid the influence of the variation of the post-abdomen. These measurements and the ratio are shown in this table.

Ratio of Head Length to Length of Head and Body.

Colorado Specimens									St. Paul Amblystoma			Amenia Specimens		
No.	Sizes	Ratio	No.	Sizes	Ratio	No.	Sizes	Ratio	No.	Sizes	Ratio	No.	Sizes	Ratio
12	$\frac{22}{60}$	37%	1	$\frac{34}{105}$	32%	10	$\frac{36}{135}$	27%	12	$\frac{23}{72}$	32%	×	$\frac{59}{192}$	31%
11	$\frac{23}{62}$	36%	6	$\frac{40}{130}$	31%				4	$\frac{22}{77}$	28%	Kenmare Specimens		
5	$\frac{23}{63}$	33%	2	$\frac{36}{125}$	29%				8	$\frac{30}{105}$	28%			
3	$\frac{23}{68}$	34%	7	$\frac{39}{130}$	30%				5	$\frac{29}{109}$	26%	×	$\frac{41}{143}$	29%
8	$\frac{33}{90}$	37%	9	$\frac{39}{124}$	31%				10	$\frac{30}{109}$	27%			
			13	$\frac{43}{135}$	32%				7	$\frac{27}{110}$	24%			
Average 36%			Average 31%						Average 27.5%					

These figures show great variation in the head length in general among these forms, so that inferences from single cases will need to be carefully guarded. Thus in the first group we find ratios of 33% to 37%, and in the St. Paul forms we find a range of from 24% to 32%. The size variation thus shown to exist would be an interesting topic for study, and has not as yet been studied. Referring now to the ratios, we see clearly that on the whole the Colorado forms have a larger head than the St. Paul forms. In the latter the ratio is 27.5%, while in the former it is 31% for the larger sizes and 36% for the smaller ones. These figures are in reality an underestimate, for they are reduced by the fact that in the comparison no allowance has been made for the tendency of smaller specimens to have larger heads. This tendency is very well shown by comparing specimens of different sizes in the foregoing statement. Thus in the St. Paul specimens it is very clearly seen, and in the Colorado forms the smaller ones have a ratio of 36%, while the larger ones have a ratio of only 31%. If the series of specimens were large enough to enable us to eliminate

individual variation, a more accurate statement of the amount of difference could be made. But if we compare a Colorado specimen with a St. Paul specimen of the same size, we find in No. 1 of the Colorado forms a ratio of 32%, while Amblystoma, No. 8, of the same size has a ratio of 28%, and the larger St. Paul specimens have a still smaller ratio than even larger specimens of the Colorado series. Thus No. 7 from St. Paul has a ratio of 24%, while the largest of the Colorado series, a much larger animal, has a ratio of 32%. One should not, however, place much reliance on the comparison of individuals, but I believe that on large series of individuals of the same size it would be found that the head ratio in the siredons is much larger.

Not only is the head as a whole larger in the aquatic forms than in the terrestrial ones, but the proportion of its parts is also different. A reduction of the head in the throat region would be expected in connection with the degeneration of the branchial apparatus, and does occur. This is seen by reference to the following statement showing the lengths of these regions of the head in a number of different Colorado and other siredons and in six St. Paul amblystomas, *viz.*:

Colorado Series			
No.	Sizes	Snout to Eyes	Eyes to Neck
12	$\frac{6}{22}$	27%	73%
11	$\frac{6}{23}$	26%	74%
5	$\frac{6}{23}$	26%	74%
4	$\frac{6}{23}$	26%	74%
3	$\frac{8}{23}$	35%	65%
8	$\frac{10}{33}$	33%	67%
1	$\frac{9}{34}$	27%	73%
6	$\frac{10}{40}$	25%	75%
2	$\frac{12}{36}$	33%	69%
7	$\frac{10}{39}$	26%	74%
9	$\frac{9}{39}$	23%	77%
13	$\frac{12}{42}$	28%	72%
Average			72%
Metamorphosing Specimen			
10	$\frac{10}{36}$	28%	72%

St. Paul Series			
No.	Sizes	Snout to Eyes	Eyes to Neck
7	$\frac{11}{27}$	41%	59%
5	$\frac{12}{29}$	41%	59%
8	$\frac{12}{30}$	40%	60%
10	$\frac{12}{30}$	40%	60%
12	$\frac{8}{23}$	35%	65%
4	$\frac{9}{22}$	41%	59%
Average			60.3%
Amenia Specimen			
×	$\frac{13}{59}$	22%	78%
Kenmare Specimen			
×	$\frac{11}{41}$	27%	73%

These figures show that the average ratio of the length of the hinder part of the head to the front part is 72% in the siredons and only 60 in the terrestrial amblystomas.

The form of the outline of the head anteriorly is another point in which the aquatic and terrestrial forms differ considerably. The difference is shown in Fig. 2. In the former the outline of the head in front is very blunt and broadly convex; in the latter the outline bends suddenly after the

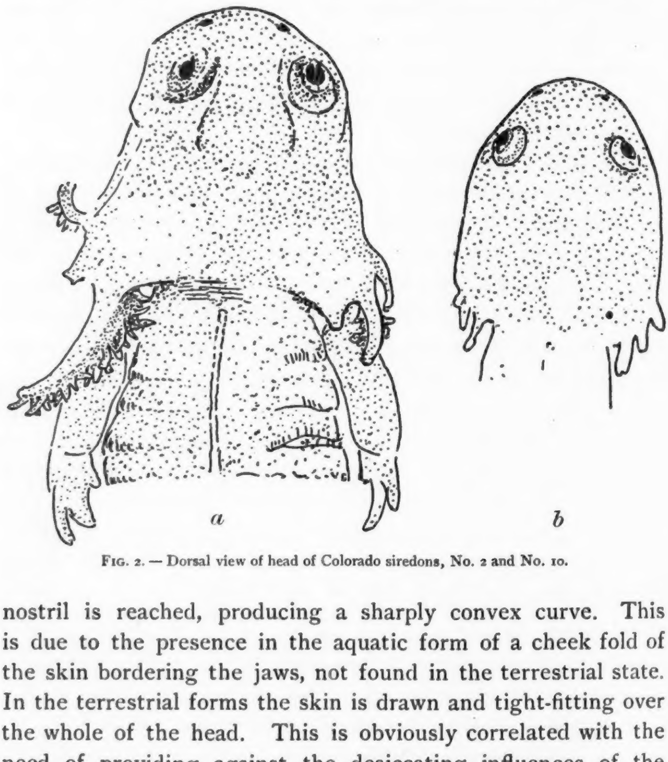


FIG. 2. — Dorsal view of head of Colorado siredons, No. 2 and No. 10.

nostril is reached, producing a sharply convex curve. This is due to the presence in the aquatic form of a cheek fold of the skin bordering the jaws, not found in the terrestrial state. In the terrestrial forms the skin is drawn and tight-fitting over the whole of the head. This is obviously correlated with the need of providing against the desiccating influences of the atmosphere. In the aquatic forms, on the other hand, the skin is very loose and ample. This is noticeable generally in the head, not only in the general skin, but in the presence of gills, opercula, and such special modifications of the outer surface.

The folds at the side of the mouth reduce the diameter of its opening. This difference in the size of the mouth is another marked difference between the axolotls and the terrestrial forms. It is indicated in Fig. 3, where the angle of the jaws is seen in 3 *a* to be anterior to the eyes, while in 3 *c* it is considerably posterior. This smaller size of mouth is perhaps correlated with the processes involved in taking water into the mouth chamber for the purpose of forcing it back and out of the sides of the throat during aquatic respiration.

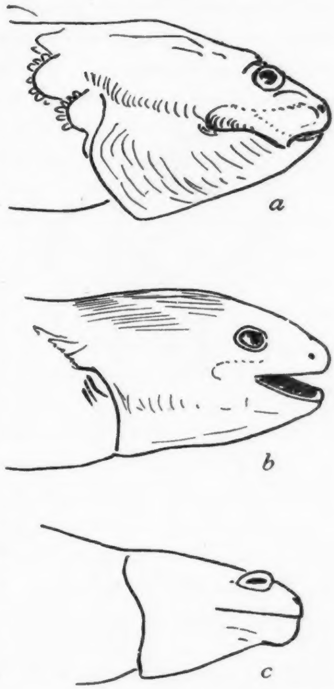


FIG. 3. — Side views of head. *a*, siredon No. 2 from Colorado; *b*, siredon No. 10 from Colorado; *c*, salamander from St. Paul.

The gills (in No. 2) do not differ essentially from the accounts and figures of Baird and others. They are shorter than the head. They are flattened outgrowths of the sides of the throat. Proximally they are continued in the floor of the throat to the hyoid bone in the center. On the underside are the opercula, thin flaps of skin, which merge distally into the under margin of the gill. The gill plates are borne on the posterior side of the free portion of the gill, which by means of a muscle running its length can be drawn back against the side of the body, thus protecting the plates. The latter are thin and placed in rows crossing the long axis of the gill. They are so arranged that two longer plates next the edge of the gill are followed by two smaller plates, set nearer to each other in the middle, as shown in Fig. 4 *a*. Many of the specimens in the collection show the gills in a state of degeneration, the gills being much shorter and the plates reduced in number.

The trunk is essentially the same in the siredon and terrestrial states, excepting as to three points, *viz.*, coloration, the dorsal fin, and the "webbing" of the toes. All of these changes have been commented on by previous writers, and may be passed without further notice.

The post-abdomen is acutely tapering from its origin to the tip. Its outline as a whole is very acute, unlike either of the Dakota specimens. It bears a very thin and membraneous "fin," which becomes noticeably wider posteriorly.

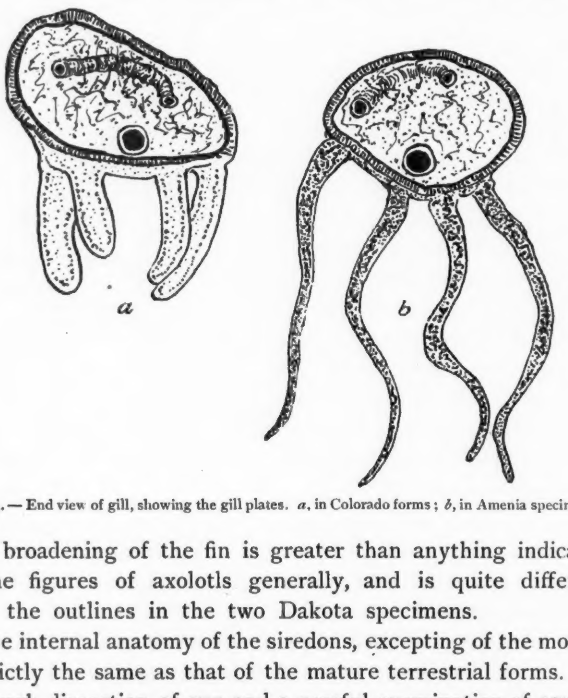


FIG. 4. — End view of gill, showing the gill plates. *a*, in Colorado forms; *b*, in Amenia specimen.

This broadening of the fin is greater than anything indicated in the figures of axolotls generally, and is quite different from the outlines in the two Dakota specimens.

The internal anatomy of the siredons, excepting of the mouth, is strictly the same as that of the mature terrestrial forms. A thorough dissection of one and a careful examination of several others of the collection demonstrated an anatomical condition of the viscera very similar to that indicated by Wiedersheim ('79) in his Fig. 1. The reproductive system in both the males and the females is fully matured, and in the females there are accumulations of eggs ready for discharge, and the albumen

glands are swollen and active. The heart and pulmonary organs have reached their final form, the former having two auricles and a connection with the lungs, and the latter consisting of the two elongate lungs communicating with the throat by means of a glottis. The siredon is thus morphologically a pulmonate or "air-breathing" animal, and so it is physiologically, for, notwithstanding its aquatic environment and branchial equipment, it uses its lungs for breathing.

A single one of the members of the Colorado series, the one numbered 10 in the list, is especially interesting, because it was taken in the act of transformation, the process nearly completed. The head of this specimen is shown in Figs. 2 *b*, 3 *b*, and 5. The general appearance of the animal is very similar to the one illustrated by Tegetmeier (**'70**). The head is intermediate in form between the aquatic and the terrestrial states. Its total length is 27% of that of the head and trunk. This is the ratio found in land salamanders, while 31–36 is that found in aquatic forms. The posterior part of the head, however, is here found not to be relatively shortened, as might at first be expected. It is 72% of that of the whole head, as in siredons, as against 60%, the ratio for land forms. As to outline in front, the head is as in the land forms, being strongly curved (see Fig. 2 *b*). The skin of the head is tightly drawn and not loose and abundant. This tension of the skin produces the bulging of the eyes noted by Marsh (**'68**) and Weismann (**'75**) among the changes of the transformation. Dorsally the head is arched, as in the land forms, and not any longer so flat as in the aquatic stage. The mouth opening is not yet as wide as it is in the definitive form. The fold at the angle of the jaws has lessened but not entirely disappeared, and the angle of the mouth is on the level of the eyes and not behind them (compare Figs. 3 *b* and 3 *c*). Ventrally the gular fold has become confluent with the floor of the mouth and throat in the center, and some distance from the middle line on each side the vestiges of the gill apparatus remain. The three clefts are still present on each side, but they have been pushed back and out from the throat, and are crowded into the small space left behind the gular fold (see Fig. 5). Structurally the apparatus is almost completely

aborted. Besides loss of length, the opercula are gone and the external parts of the gill are reduced to mere warty lumps. On the floor of the mouth the tongue had not yet developed. The trunk region is also intermediate and presents both siredon and salamander features. The coloration is still of the aquatic kind, showing no hint of the future dense black general tone spotted with irregular blotches of brilliant lemon yellow so characteristic of the land forms of the species. On the other hand, the dorsal fin is wholly absorbed, and the toes are no longer "webbed"; instead, the skin fits closely and the toe is cylindrical and tapering. With this change of the toes and the fins the power of locomotion by swimming in water must be very considerably diminished. The post-abdomen has also reached the final form, the tail fin being nearly completely absorbed.

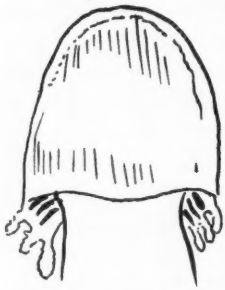


FIG. 5.—Ventral view of the head and throat of siredon No. 10, showing the transition to the terrestrial form.

Tegetmeier reports in 1870 his observations upon a transforming axolotl. His account is very brief. He says: "The specimens were hatched in the summer of 1868, and kept under similar conditions without any change having taken place beyond steady increase of growth during the succeeding winter and the summer of 1869. In the autumn one began to change; the external gills disappeared, the jaws became more pointed, and the skin assumed a singularly mottled appearance. The animal did not leave the water, but when the temperature was warm usually breathed by standing erect against the side of the aquarium and elevating the nostrils above the surface; during the cold weather it usually remained submerged, rising at intervals to breathe." This case of Tegetmeier's seems to be like the Colorado specimen in that the metamorphosis took place while the animal still maintained its habits of aquatic life. Apparently the same may be said of the transformations reported on by Marsh ('68), Dumeril ('70), and Chauvin ('75).

We do not know the cause of the transformation of the siredon. In the St. Paul form of Amblystoma the animal first

becomes terrestrial and afterward matures. We have come to regard the land forms as mature, when as a matter of fact the aquatic form may be just as truly mature, since its organization, excepting in a few minor points, is identical with that of the land forms. There are two kinds of transformation distinguishable in the metamorphosis of an Amblystoma. One of these is in the development of the limbs, the alteration of the circulatory system, the development of the lungs, and the maturing of the organs of reproduction; these may be considered as the primary adult characteristics. In addition to these are a number of secondary changes, which do not involve radical morphological processes, but are largely confined to points in the external anatomy. These latter are secondary adult characteristics. The whole axolotl question turns on these secondary characteristics; for, as to the primary changes, they take place alike in axolotls, siredons, and salamanders, and one is as truly adult as the other. But for some reason an interval has arisen in axolotls and siredons between the primary and the secondary changes, so that instead of all of them progressing *pari passu*, the secondary changes are postponed, and take place either much later or not at all. In the neighborhood of St. Paul, amblystomas are fully adult when only 100 mm. in length, perhaps even less. In the Mexican axolotl, when the animal reaches this length, the secondary transformations do not take place, though the primary ones do, and the animal thus remains aquatic, though adult in all other respects. In the siredons we find that the condition is intermediate; instead of secondary transformation being indefinitely postponed and not taking place at all, it takes place much later. In specimen No. 10 it is taking place after the animal has reached a length of 235 mm. instead of having occurred at only 100 mm. In No. 2, of the same size and apparently from the same environment, it has not taken place, and no signs of its approach are visible.

FIG. 6.—Side view of the specimen from Kenmare, North Dakota.

II. THE SPECIMEN FROM KENMARE, NORTH DAKOTA.

The axolotl referred to in the former article (*American Naturalist*, July, 1900, p. 544) as having been found in Kenmare, North Dakota, has been kindly loaned to me for examination by its owner, Mr. W. H. Makee of Kenmare. It was somewhat injured by cutting in the throat, possibly when it was captured, and has been somewhat distorted by preservation in too small a bottle; still it is adequate for study and comparison with the Amenia specimen. As it had been preserved in alcohol, while the Amenia specimen was preserved in formalin, and as the Kenmare specimen was somewhat distorted in fitting it into its bottle, the measurements of the latter will not stand a rigid comparison with those of the other siredons.

Mr. Makee writes me as to the locality of the specimen, that it was caught among a number of fish in a seine during June, 1898, in Des Lacs Lake. The lake is thirty miles long and half a mile wide, and has an estimated depth of twenty-five feet. It is located in Ward County, North Dakota, and discharges through a chain of lakes into the Mouse River, a tributary of the Red River of the North, and finally of Hudson Bay. Kenmare is at

the opposite end of the state from Amenia, and is the most northern locality from which siredons have been reported. The coloration resembles the Amenia specimens and is unlike that of the forms from Colorado. It is dark above, excepting in a narrow tract on each side of the dorsal skin fold. There are numerous dark rounded distinct spots, the largest of which have a diameter of 4 mm. The spots are scattered over the body and post-abdomen and on the upper surface of the head. They are more numerous and larger than in the Amenia form. The undersides of the trunk and head are several shades lighter in color than is the case in the Amenia specimen. The skin is smooth, as in the Colorado specimens. The "coarse and warty roughness" of the Amenia form is not found in the Kenmare specimen.

The appearance of the Kenmare specimen is shown in Fig. 6. With the exception of its gills, it is more like the Amenia form than it is like the Colorado specimens. Its dimensions are shown in the table at the end of this article.

The head in the Kenmare specimen is shorter relatively to the length of the head and trunk than it is in the Colorado forms. This can be seen best by means of a table, thus:

Ratio of Head to Head and Trunk in

(*a*) the Kenmare specimen	29%
(*b*) the Amenia specimen	31%
(*c*) the Colorado specimens	34%
(*d*) the St. Paul specimens	27%

The injury of the head made it difficult to be sure of the length of head within 1% or 2% in the Kenmare specimen, but even so, the head is much shorter in both of the Dakota forms than in the Colorado specimens, and more nearly the length that is characteristic of the terrestrial forms. Too much stress should not, however, be laid on this fact, as the measurement is based on a single specimen in each case, and some of the single ones of the Colorado series have the head as short as 29%, as in this specimen.

The length of the head behind the eyes is also interesting here. Tabulating this measurement in the four cases, we find that the posterior length is

(*a*) in the Kenmare specimen	73%
(*b*) in the Amenia specimen	78%
(*c*) in the Colorado series	72%
(*d*) in the St. Paul series	61%

of the total length of the head. In this respect the Amenia specimen is very extreme, and the Kenmare specimen agrees with the rule for siredons, as determined by the Colorado series.

The head is also blunt anteriorly, as in general. The gular fold in the Colorado forms, as in siredons generally (see Baird, '52, Fig. 3), is emarginate, and this is the case in the Kenmare specimen, unlike the Amenia one.

The gills are three on each side. They are vertical outgrowths of the side of the throat, flattened so as to present a dorsal and a ventral margin ; the latter, at the base of the gill, is continued inward under the branchial bone to form a thin flap, the operculum, which covers the gill slit in the floor of the throat (see Fig. 6). The gill presents two surfaces — one anterior, the other posterior. The former is naked, the latter bears the thin triangular plates in which the capillaries are placed which expose the blood to the aërating action of the water. The gills can be bent by the contraction of a muscle located within them, so that the posterior side is parallel to the body, and the gill plates are thus covered and protected.

There are four rows of gill plates. Two of the plates are larger and more external. They are on the same level, and are followed by two smaller and more internal plates. Each one of the plates is a tall triangular and flattened structure. At its base a blood vessel can be seen entering on one side. Capillaries filled with blood corpuscles can be seen in the interior, and running through the gill in the center and near the bases of the plate is a large vessel. The blood vessels are deeply pigmented, and the surface of the plates is minutely spotted with black branching chromatophores.

The gills differ from both the Colorado and the Amenia specimens. The lengths of the filament-bearing areas of three gills in succession, beginning with the anterior one, are respectively 76%, 90%, and 125% of the length of the head in the Kenmare specimen. The corresponding figures for the Amenia specimen are 76%, 90%, and 117%. For the Colorado forms they are, in case No. 21, 33%, 50%, and 72%. In both the Dakota specimens the gills are thus noticeably much longer than is the rule among siredons, as hitherto reported, and among the Colorado specimens which are in the main in accord with the cases reported by Baird, Marsh, and others. The gill in the Kenmare specimen does not broaden distally, but is tapering from base to tip. This is in contrast with the Amenia specimen, where the gills are spatulate in form, which point may, however, prove to be an abnormality. The form of the gill plates in the Kenmare specimen is different from either those from Colorado or the Amenia specimen. They are not long and filamentous as in the latter, and they are not short and blunt as in the former; but they are wide and plate-like, tapering to the tip, the outer row being longer than the inner; they are arranged as in the Colorado forms.

The body offers nothing for special comment. The coloration has already been mentioned, and the feet show the same broad foot margin of skin on the sides of the toes as is found in other siredons. The post-abdomen and the fin are much as in the Amenia form and decidedly unlike the siredons generally and the Colorado series. The body part is heavy and broad from base to tip; it is broadly convex at the tip, in marked contrast with the acute taper found in all the Colorado series. The fin is thick and strong, contrasting with the thin membranous texture of the Colorado forms, and it is not so wide as in them. In all of these points the post-abdomen is like that of the Amenia specimen.

An examination of the internal anatomy was made only in so far as it could be done by means of a short incision in the side wall of the body. Through this it was possible to see the lungs fully developed, as in a strictly terrestrial form, and the various viscera were similar to those found in the St. Paul material.

The sexual organs were not in an active state; a large *corpus adiposum* is present, and behind it a small elongate but not distended genital organ, which upon examination proved to be an ovary containing numerous slightly developed but recognizable eggs. I did not find any evidence to show whether the animal had ever laid eggs or was still immature, but the latter supposition seemed more likely.

BIOLOGICAL LABORATORY, HAMLINE UNIVERSITY,
ST. PAUL, MINN., April 18, 1901.

LITERATURE REFERRED TO.

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'59 BAIRD, S. F. *Rep. U. P. R. R. Survey.* Vol. x, Pl. XLIV.
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'68 MARSH, C. C. *American Journ. of Sci.* Series 2, vol. xliv.
'00 OSBORN, H. L. *American Naturalist.* Vol. xxxiv.
'70 TEGETMEIER. *Proc. Zoöl. Soc. London.*
'75 WEISMANN, AUGUST. *Zeitschr f. wiss. Zool.* Bd. xxv.
'79 WIEDERSHEIM, R. *Zeitschr. f. wiss. Zool.* Bd. xxxii.

Table of Measurements.

Catalogue Number.	Colorado Specimens 12.	11.	5.	4.	3.	8.	1.	6.	2.	7.	9.	10.	13.	Kenmare Specimen.	Amenia Specimen.	St. Paul Specimens of *Amblystoma tigrinum* 7.	5.	8.	10.	12.	4.
Chin to tip of tail	108	108	113	123	120	155	190	206+	220	250	235	232	245	245	312	190	190	204	200?	125	125
Chin to margin of gular fold	16	17	16	17	19	25	24	30	27	30	28	29	32	30	35	26	23	26	27	18	17
Chin to post. edge of cloaca	60	62	63	69	68	90	105	130	125	130	124	135	135	143	192	110	109	105	109	72	77
Snout to level of bases of inner gills	22	23	23	23	23	33	34	40	36	39	39	36	43	41	59	27	29	30	30	23	22
Greatest diameter of head	18	19	20	19	21	27	31	35	38	38	33	31	34	38	55	21	21	23	22	15	15
Width of mouth	09	08	09	10	12	13	14	19	20	18	18	20	—	23	30	—	—	—	—	—	—
Distance between nostrils	06	06	06	06	06?	08	10	11	10	10	12	11	—	09	14	7	7	8	8	7	—
Distance between centers of eyes	11	11	11	10	12	14	16	20	18	20	18	18	—	20	26	15	14	17	15	11	11
Width of head at eyes	15	15	17	17	18	24	24	32	30	31	28	24	—	33	39	18	18	18	18	13	13
Snout to line joining centers of eyes	06	06	06	06	08	10	09	10	12	10	09	10	12	11	13	11	12	12	12	8	9
Length of filamentous border of gill 1	06	08	06	05	08	10	10	23	12	12	05	04	—	27	45						
Length of filamentous border of gill 2	06	08	06	05	12	09	10	15	18	12	05	04	—	42	53						
Length of filamentous border of gill 3	06	08	05	05	12	09	09	15	26	15	05	04	—	50	69						
Length of arm	06	07	06	07	07	12	15	15	12	15	14	13	—	19	24						
Length of fore-arm	06	05	05	07	07	09	11	15	11	12	13	13	—	17	17						
Length of hand	06	06	06	08	07	11	12	16	14	14	14	13	—	16	19						
Length of leg	06	06	08	09	07	12	12	15	13	15	14	15	—	14	19						
Length of fore-leg	06	06	07	07	07	09	12	15	13	13	14	15	—	15	19						
Length of foot	06	06	08	10	08	13	15	16	15	20	15	17	—	21	22						
Greatest height of tail	07	07	06	08	08	10	13	17	15	15	16	15	—	26	32						
Greatest thickness of tail	04	04	05	07	06	07	07	10	13	10	09	09	—	15	18						
Greatest height of dorsal fin	07	07	08	10	11	09	12	10	13	15	13	0	—	08	08						

A PARASITIC OR COMMENSAL OLIGOCHÆTE IN NEW ENGLAND.

M. A. WILLCOX.

Chætogaster limnæi von Baer appears to be the only oligochæte which is generally recognized as a parasite ; at least it is the only one to which Michaelsen in his recent work on the subclass (*Das Tierreich, Oligochæta*, 1900) ascribes such habits. The species has been reported only from Europe, and it is therefore with pleasure that I am able to announce the discovery in the neighborhood of Boston of a very similar form, regarding which I can at present give only the following incomplete notes.

The worms were first found about the end of May, 1901, infesting a species of Physa, probably *P. heterostropha*, which was obtained in a small stream in Wellesley. They were also afterward observed upon an undetermined species of Planorbis. They were abundant about the head and in the respiratory cavity. In a few instances the hinder part of the body seemed to be imbedded in the tissues of the snail, but of this I cannot be sure. Most of them certainly were entirely free, and, waving about like tiny white threads, had much the appearance of a fungus. Occasionally I have noticed them, like the European form, crawling over the outside of the shell; but they ordinarily restrict themselves to the body of the snail.

This is undoubtedly the animal mentioned by Gould (*Report on the Invertebrate Animals of Massachusetts*, 1841, p. 213) under the name of *Gordius inquilinus* Müller, and supposed by him to be a parasite of *P. heterostropha*. In none of the specimens taken under ordinary conditions, however, did the alimentary tract give any indications of a parasitic habit ; on the contrary, I have seen in it no other food than diatoms. It will be remembered that Lankester in his description of the European form ("A Contribution to the Knowledge of the Lower Annelids," *Trans. Linn. Soc.*, Lond., Vol. XXVI,

pp. 631–646, 1870) speaks of finding the worms in winter within Limnæa, and gorged with the kidney cells, while he seems to have found no such evidence of parasitism at other seasons. I should add that in one instance, in which the worms had been left for some time in a watch glass with a torn Physa, the alimentary canal of almost every one was found stuffed with the blackish pigment characteristic of the snail, which was floating in the water.

The worm is a small, transparent animal, about 2 mm. in length and 1–5 mm. in breadth at its widest point. Both these measurements are taken in extension, but as the creature reproduces by fission, and as colonies of at least three persons are common, the first impression is of a much longer organism than I have described. On the ventral side, near the anterior end, are two clusters of cephalic setæ ; each seta is sigmoid, about 1–14 mm. long, and ends in a fork whose prongs are equal and are bent nearly at right angles to the shaft ; each cluster ordinarily contains seven setæ, though there may be six or, very rarely, five. In one case, one side bore the full number of seven, while there were but two on the other. It would seem probable that the remaining ones had been torn away. At some little distance behind these clusters are the abdominal ones, which differ from the former only in that the setæ are smaller (about 1–23 mm. in length), more numerous (being, as a rule, eleven, rarely ten, in a cluster), and borne on a slight projection of the body which apparently corresponds to a rudimentary parapodium. This last peculiarity, combined with a habit of holding the hind end fixed while extending and waving about the anterior one, gives the worm, as Lankester has already remarked, a curious likeness to a geometrid larva. There are sometimes as many as thirteen pairs of seta clusters behind the cephalic one ; it is difficult to determine how many of these should be reckoned as belonging to a single individual, but for reasons which will be given in discussing the budding, I am inclined to consider with Lankester that the adult has four pairs of abdominal clusters.

The large mouth lies at the anterior end, but the dorsal edge projects rather over the ventral one, so that the tip of the body

in side view appears obliquely truncate. The mouth leads directly into the pharynx, which occupies rather more than one-third the length of the animal, is extremely distensible, and is connected by muscle bundles to the body wall. The pharynx is succeeded by an œsophagus so short and narrow as to be, when the other parts are greatly dilated, quite indistinguishable. Next comes the stomach, which as seen in optical section is nearly square and is separated by a constriction from the intestine. This division is somewhat longer than broad, and its walls are usually characterized by a yellowish brown hue, sometimes to be observed also on the stomach and suggesting the chloragogue cells of Lumbricus. Opposite the third abdominal setæ is a constriction, at which point this yellow color suddenly disappears. The remaining part of the intestine varies in shape according to the degree of development of the buds. The hind end of the worm is slightly notched.

The stomach is often found filled with diatoms, with which are likely to be intermingled a few pebbles. The other parts of the alimentary tract, if not entirely empty, are usually nearly so.

There are five septa: one opposite the anterior and one opposite the posterior end of the œsophagus; one at the constriction between stomach and intestine, one opposite the middle of the intestine, and one at the point of its posterior constriction. Behind the fourth abdominal setæ is a zone in which the cœlom may be absent, and behind this region may appear the cœlom of the bud.

The large blood trunks are a dorsal pulsatile and a ventral non-pulsatile one. They are connected by a pair of pulsatile vessels which encircle the œsophagus. Lankester has figured a pair of anterior ones extending obliquely down and back around the pharynx; I have seen such vessels, but am not sure of the way in which they connect (as they undoubtedly do) with the longitudinal ones. The blood is colorless.

Of segmental organs I have observed only three pairs; they appear as coiled granular organs in the last three segments. I have not found them in the segment which corresponds to the anterior abdominal setæ.

The nerve cord is a fibrous-looking band encircling the œsophagus and running back along the ventral wall. In the region underlying the pharynx the ventral cords, although close together and connected by several cross branches, are perfectly distinct; this portion sometimes shows clearly in living specimens, and I have remarked in it no ganglionic swellings. In a stained and mounted specimen, however, when seen in profile, two ganglia are clear and there are traces of a third.

Upon the reproductive system I have made no observations. The worms at the season at which I examined them appeared to have these organs undeveloped.

Every animal examined was in process of active budding. A comparison of different stages indicates that this process takes place in the following way. The first part to be formed is what I may call the abdominal portion; that part, namely, which bears the abdominal seta clusters and which consists in the adult of four segments. These segments arise by terminal budding from the parent; when two of them have been formed so that there is a series of six in all, there arises between the third and fourth a zone in the anterior part of which is differentiated a terminal segment, the fourth segment of the parent, while its posterior part is converted into the anterior part of the bud. During this process of differentiation another segment has arisen at the terminal end of the chain, so that when its anterior end is complete, the bud has four abdominal segments. Before it breaks away from the parent, however, a new individual has begun to develop between the two.

The series upon which these conclusions are based consists of the following stages: *a*, a terminal bud just ready to break away, and possessing four abdominal segments; *b*, an older individual with five abdominal segments, the fifth one the youngest, as shown by its size and by the number and development of its setæ; *c*, one with six abdominal segments present, but a zone as yet undifferentiated into segments between segments 3 and 4; *d*, a similar specimen, except that a seventh segment has been added at the hind end of the chain; *e*, a specimen like *d*, except that two pairs of seta clusters are developing in the hitherto undifferentiated space between segments

3 and 4 ; *f*, one like *e*, but with a deep groove formed between the two sets of developing setæ.

Before the bud breaks away from the parent, a new individual has begun to develop between the two. In my experience, which has extended over only a single month, it has been rare to find a chain consisting of more than three persons, and as in such chains the older bud is often so far developed as to be readily detached from the rest by the pressure of the cover, I am inclined to doubt whether colonies of as many as sixteen zoöids (*cf.* Claus, *Würzburger naturwissenschaftliche Zeitschrift*, Bd. I, pp. 37–40, 1860) are ever found in our form.

Upon comparing this description with that given by Lankester for the European form, it will be seen that the only important difference which has been shown to exist relates to the number and arrangement of the setæ in the different bundles. I am uncertain how much importance should be attached to this difference. Lankester describes his species as having twelve setæ in the cephalic bundles and eight in the abdominal ones, and after having for more than three years "taken every opportunity of examining the little worms" states that this number is "almost invariable" (*Quart. Journ. Micr. Sci.*, N.S., Vol. IX, pp. 272, 276). Vejdovsky, on the other hand (*System und Morphol. d. Oligochaeten*, p. 36), in describing the same species, says : "Bezüglich der Anzahl der Borsten variieren die Bündel bedeutend, indem man auf den hinteren Segmenten gewöhnlich eine grössere Menge derselben vorfindet als in den vorderen Borstenbündeln. Im allgemeinen trifft man in einzelnen Bündeln, 8, 9, 10, 10–12 Borsten." I have not, however, in an incomplete but somewhat careful review of the literature, been able to find published authority for this statement of Vejdovsky.

In view of this uncertainty and of the fact that Lankester's paper, which contains the only full anatomical description of the European species, is somewhat difficult of access, it has seemed worth while to give a fairly full account of our own form. Lankester's plates are so complete and so admirable that it has not seemed desirable to add illustrations to this description.

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OBSERVATIONS ON THE BREEDING HABITS OF AMEIURUS NEBULOSUS.

ALBERT C. EYCLESHYMER.

Although the bullhead, or horned pout, is one of the most common of our fishes, but little was known of its breeding habits until Professor Birge, several years since, discovered the nests and eggs and made some interesting observations on the behavior of the fishes during the spawning period. The earlier naturalists had given us hints as to the breeding time, but these suggestions were little more than indefinite surmises, partaking of the character of the following remarks by Thoreau: "The horned pout are dull and blundering fellows, fond of the mud, and growing best in weedy ponds and rivers without current. They stay near the bottom, moving slowly about with their barbels widely spread, watching for anything eatable. They will take any kind of bait, from an angleworm to a piece of tin tomato-can, without coquetry, and they seldom fail to swallow the hook. They are very tenacious of life, 'opening and shutting their mouths for half an hour after their heads have been cut off.' They spawn in spring, and the old fishes lead the young in great schools near the shore, seemingly caring for them as the hen for her chickens. A bloodthirsty and bullying set of rangers, with ever a lance in rest, and ready to do battle with their nearest neighbor."

While the observations made by Professor Birge have never been published, some of the facts have been given me in a private letter, from which I have permission to quote. Professor Birge writes: "The bullheads on which I made my observations made their nests in a shallow bay with sandy bottom, in water not more than two feet in depth. Some of the nests were in water not six inches in depth; hardly deep enough to cover the male while sitting on the eggs. This bay was overflowed land and contained numerous stumps, which had become hollow in the

course of time, and perhaps three of the nests were in these stumps, to which access was easily gained by the spaces between the roots. The others were among weeds and differed considerably. One or two bullheads kept the weeds away from the eggs, so that it was not difficult to see the nest from the shore, while others were concealed so that it was almost impossible to see the eggs or fish without removing the weeds from above them.

"There was a surprising difference in the disposition of the fishes on various nests. One of them was extremely tame. If approached cautiously he would not swim off, and it was quite easy for me to put my hand under him and lift him off the nest. He seemed to enjoy being scratched gently, and when lifted off the eggs would remain where placed or would swim off a short distance, and, in general, was very little disturbed by handling. Others were exceedingly shy, so that as soon as one had approached within a few yards of them they would dart off, throwing the eggs out of the nest as they went, with a jerk of the tail. Of course they always came back and brought the eggs together again. But this violent treatment of the bunch of eggs was apt to break it up, and I observed that a considerable portion of the eggs was lost in such cases. One of the catfish, whose eggs were in a stump, was particularly ferocious, and this was the only one which I found that had a violent disposition. I found the nest and put my hand down into the stump to take some of the eggs, when the fish seized it and worried it with all his force. After that, I found it necessary to remove the eggs from this nest with a pair of long forceps, which the fish would bite in spite of being rapped on the nose with them rather vigorously. It was this difference in disposition that especially attracted my attention in studying the catfish."

In June, 1892, I secured a number of bullheads from the small ponds in the vicinity of Worcester, Mass. Some of these contained ripe ova and sperm, and an attempt was made to artificially fertilize the eggs, but with ungratifying results. Many eggs passed through the cleavage stages, but all perished before the embryos were discernible. Although repeated efforts were

made to find the nests, they were unsuccessful until June 8, 1896, when three nests were found in Fowler Lake, Wis. Two of these were in pieces of stovepipe, the third in an old pail. The nests were in clear water, near a bold, rocky shore, and at a depth of four or five feet; all contained embryos, and each was guarded by a parent fish, — which one I did not ascertain. On the following day, in searching for other nests, I raised a small piece of tin pipe and was surprised to find a pair within. Through the raising of the pipe they became so wedged that it was impossible for either to get free. They had not yet begun spawning, although the eggs were so ripe that they were easily extruded by slight pressure. Artificial fertilization was again tried, but was only partially successful. A small percentage of the eggs segmented, most of which died before the embryos appeared.

During the month of June, 1898, I chanced to camp near Mud Lake, Mich., and learned from the fishermen that the lake abounded in large bullheads. An extended search was made on June 9, 10, and 11, and we had almost given up the search when one of my companions found a nest in a small bay with shallow, sandy shoals. Soon a dozen or more were found along this sandy shoal, and in a depth of water not exceeding three or four inches. They were usually concealed beneath logs, stumps, or boards, which lay against the bank. One would often observe a slight depression, and upon turning the sheltering object would find the pair engaged in spawning or watching over the freshly laid eggs. In two nests which were found beneath logs on June 11, the parent fishes were moving about in the small sheltered excavation. The eggs were removed in each case; those of one lot were in early cleavage, while those in the other were in late gastrula. Both nests were visited on the following day, but the fishes were no longer present. Another nest, in which the eggs were in late gastrulation stages, was uncovered and left exposed. When visited on the next morning neither fish nor eggs were found. I suspect that the eggs are devoured by the parent fish when the nests are too much disturbed, as is known to be the case with some of the Amphibia. I have, on several occasions, found eggs in

the stomach of Necturus. In one instance I partially removed the eggs from a nest, and upon returning the next day found the old Necturus in the nest as usual, but the remaining eggs could not be found. The parent was taken, and an examination revealed the fact that a number of eggs had been swallowed.

It was interesting to watch the actions of the fish when the sheltering object was removed. A fence rail covering a nesting pair was carefully turned, when the fishes immediately sought its shelter. As it was turned farther and farther from the nest they followed, keeping as well secluded as possible, the while moving restlessly about in search of the nest. When the rail was finally lifted from the water the male lingered for a few moments, then darted for deeper water. The female approached the shore and began searching here and there for her lost nest. This she passed several times without recognition, although she seemed to know the surrounding landmarks, since she would go but a short distance in either direction, then turning would pass back to the locality of the nest, which she found in a short time, and despite the fact that it was unsheltered, she remained. On the following morning the nest was visited, but again neither fish nor eggs were to be found.

It is not difficult to allure the fish to an improvised shelter. A number of boards were placed on the shore with one end projecting into the shallow water. The fishes sought these places and made their nests beneath the boards. It is worthy of note that in no case did I observe more than a single nest beneath the same cover, and this quite agrees with the pugnacious character of the fish.

Two nests which were occupied by both parent fishes were left undisturbed and when visited two days later only one fish was present. It was found by examination that in each case it was the male. When the female leaves the nest could not be definitely determined; as nearly as could be ascertained it would seem to be about the time the embryos begin to move.

The eggs are laid in masses, quite unlike those of most fishes, but similar in general form to the egg masses of the common frog. They are free from pigment and present when beneath

water a rich creamy color. The period intervening between deposition and the beginning of cleavage is not precisely known. After cleavage has begun it continues rhythmically as long as it can be followed, the intervals between successive cleavages being about thirty minutes. In forty to fifty hours after the beginning of cleavage the embryo is plainly visible, measuring 2 mm. to 2.5 mm. The larvæ at the time of hatching are about a week old and measure 7 mm. to 8 mm. When they break through their surrounding envelopes they are quite unable to support the load of food yolk, but lie on their sides, now and then making a few vigorous movements. In the course of a few days they are able to swim about and soon leave the nest accompanied by the male fish.

During the early summer of 1899 I was able to make some further observations on the habits of the larvæ. In one of the drainage ditches on Cottage Grove Ave., Chicago, they were so numerous that in walking a distance of a hundred yards one would see from seventy to eighty schools. The larvæ are usually huddled so closely together that they form a dark mass, which at a distance appears as a shadow moving to and fro. They rarely move in straight paths, but are ever circling, apparently in quest of food. When they come in contact with aquatic plants they pause, carefully search over the leaves, and again join in a common movement for other grounds. Frequently one departs from the company and darts here or there after an insect which may be passing along the surface of the water. One never observes them at rest, as is common for the adult. During the night they seem to be especially active, since it is during this time that they jump over the edges of the hatching dishes.

The broods vary widely in numbers; one occasionally observes a group of forty or fifty and again one containing several hundred. It was at first thought that either the number of eggs deposited by the different fishes varied accordingly, or that a much greater percentage survived in some cases. While both these factors probably modify the numbers, the chief cause of these wide variations was discovered one day when I chanced to observe four good-sized groups of larvæ

approaching a common point. I awaited with interest their movements and was surprised to see them unite to form a single school, which, however, remained intact but a short time. The larvæ soon separated into three groups, each of which pursued a different course. This procedure was repeatedly witnessed, sometimes the union of small groups to form a large one, again the subdivision of a large one. The fact that the larvæ in some of the broods vary widely in size is thus easily explained. A slight disturbance of the water is sufficient to disperse them, after which they again join in a closely aggregated group. A shadow cast upon the water and quickly removed sends them scurrying here and there. I was quite surprised to discover that a low guttural sound caused them to disperse, while a shrill whistle caused no commotion.

During the summer of 1900 I was able to make some observations on the behavior of the fish preceding the spawning. While observing the habits of the black bass in the artificial ponds of Oakwoods Cemetery, Chicago, I saw a number of large bullheads swimming about singly and close to the shore. I thought at first that they, like many of the other fishes in the lagoons, were exceedingly tame and had sought the shallow water for the purpose of obtaining food. After several ineffectual attempts to induce them to take worms, bits of meat, bread crumbs, etc., I concluded that they were not feeding, and since from previous observations I knew this to be their spawning time I surmised that they might be searching the shore to locate suitable nesting places. They would frequently swim so far into the shallow water that the dorsal fin and upper portion of the body were above the surface of the water. Here they would wriggle about, and if an indentation or slight excavation were found they would pass in, move rapidly about, swim out and on, only to repeat the procedure when another suitable locality was found. The fishes were always single; in no case were two observed even in close proximity.

On May 15 and 18 increasing numbers of these wanderers were observed. On May 20 I was gratified to witness what seemed to me a natural sequence. A cloud of muddy water attracted my attention, and walking cautiously to within a few

feet of the spot I waited until the turbidity cleared, when I saw a large bullhead lying motionless on the bottom and at a depth of eight to ten inches. After a period of some five minutes she swam close to the shore, placed her head in a slight excavation, and with a violent action of the entire body threw up another cloud of mud. When the water again cleared she was observed a short distance from the excavation. At short intervals the process was repeated. The excavation was being made in soft clean sand and beneath the sod bank which formed the shore of the lagoon. I had watched the movements of the fish for a half-hour or more when a second fish appeared and at once began to excavate in a manner similar to that noted for the former, the first fish meanwhile lying motionless a few feet away. Although both fishes were pretty well covered with sand, a number of differences were observed. The latter was much darker than the former, the abdomen a brighter yellow with less protruding abdominal walls, and although about the same size, I concluded that the latter was the male and that they had mated. While the excavating was now done by one, now by the other, it seemed that the female took the more active part. After watching the actions of the pair for an hour or more I retired and did not again visit the nest until the morning of the following day, when both fishes were again observed at work in the same manner as on the preceding day. The excavation was now deep enough to almost entirely hide the fishes, the tips of their tails barely showing. The nest had been greatly enlarged, as was evidenced by the quantity of sand which had been thrown out and which now covered an area of about three or four square feet, with a maximum depth of four or five inches. The top of this little mound was hollowed out into a deep, saucer-like depression from which a broad groove led to the nest.

On the next morning there were further indications that the excavating had been continued, but no evidence of its being still in progress. The female was at this time observed lying in the saucer-like depression, from which she soon departed. After considerable jarring over the nest the male was frightened out. I was not permitted to disturb the bank of the lagoon,

and consequently was not able to make observations on the interior of the nest; by reaching back in the hole a distance of sixteen to eighteen inches I could feel the egg mass, and upon the removal of a portion of the eggs found them to be in late cleavage stages, and from previous observations inferred that they could not be more than twelve hours old.

The above fragmentary notes embody, so far as I am aware, the first published observations on the behavior of the bullhead during the breeding period. They are recorded with the feeling that they may be of service to those who have so long sought the embryological material of this primitive teleost. I may further remark that a study of the breeding habits under natural conditions shows that Ameiurus rarely burrows in nesting, but instead seeks concealed places beneath logs, stumps, boards, or even pails or other receptacles which are easy of access. If, however, a modified environment replaces the natural, and the places for concealment be no longer present, as in the artificial ponds, we find the fish adapting themselves to this changed condition and constructing nests which often require two or even three days of unceasing labor to prepare.

In closing I cannot refrain from suggesting that a more extended series of observations would doubtless show that other fishes, like Ameiurus, manifest an entirely different behavior during the spawning period as a direct adaptation to the changed environmental conditions. Indeed, my observations on the dogfish (Amia) and the black bass living in the artificial ponds indicate that this is true of these forms as well.

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THE SPERMATOGENESIS OF ONISCUS ASELLUS LINN., WITH ESPECIAL REFERENCE TO THE HISTORY OF THE CHROMATIN.

M. LOUISE NICHOLS.

THIS study was begun in February, 1899, and finished in January, 1901. Its more important results are described in this paper. A more complete and detailed account of the spermatogenesis will appear in a later publication.

I. STRUCTURE OF THE TESTIS.

Each one of the two testes consists of three narrow lobes, distinct from one another and opening successively into the anterior expanded portion of the vas deferens. The interior of each lobe or follicle is occupied by the germ cells, which are in differing stages of development in the three follicles of one side. Each follicle may be divided into two principal regions of growth, composed of cells of different generations and of differing degrees of development. The illustration (Fig. 1) will make this clear.[1] It shows, in a typical case, the comparative degrees of development to which the cells of the three follicles have attained. Thus, in the most posterior of the

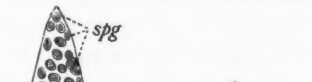

FIG. 1.—Testis of *Oniscus asellus* Linn. *a*, *b*, *c*, follicles of testis; *vas*, anterior part of vas deferens; *f.c.*, follicle cells; *spg*, spermatogonia.

[1] This and the following figures are slightly schematic.

follicles (*a*) the apical third is occupied exclusively by spermatogonia, some of which can be seen in mitosis ; the basal region, on the other hand, by spermatids in an immature state. Follicle cells occur on the outside of the follicle, being especially abundant in the basal region. In the adjacent follicle (*b*) the apical two-thirds is occupied by cells in the synapsis stage, the remaining portion by spermatids in a stage of development later than that of follicle (*a*). Along the margin of the follicle are found scattered small groups of spermatogonia (*spg*). The third and most anterior follicle (*c*) contains chiefly spermatocytes in a late prophase. Groups of spermatogonia similar to those of follicle (*b*) are here also found scattered along the margin and nearly filling the extreme apical portion. The follicle cells in the basal region are undergoing not only active amitotic division, but to a certain extent degeneration. Their active multiplication or fragmentation causes them to crowd in towards the axis of the follicle.

From a comparison of the extent of these growth regions in the three follicles, the developmental cycle may be conceived somewhat as follows. The spermatozoa, when fully formed, are forced into the vas. Since they have no motion of their own, this is probably caused by the contraction of the muscle layer of the follicle, perhaps assisted by the pressure of the growing cells in the apical region. During this process the spermatogonia in the apical portion of the follicle divide and come to fill up the space left vacant by the discharged sperm. The majority of the spermatogonia thus filling up the follicle proceed in their development, while the remainder form the groups of cells along the margin of the follicle already described in follicles (*b*) and (*c*), and which are destined to supply a new generation of cells. The spermatids also proceed in development and are forced into the vas.

A condition like that represented in follicle (*b*) thus arises, the basal region filled with spermatozoa in a late stage about to pass into the vas deferens, and the apical region with cells which have progressed as far as the synapsis stage. Later, the spermatozoa having been completely discharged, the cells of the apical region come to occupy the basal part of the follicle,

being now less compactly pressed together (*c*). Their development progresses until, having become mature spermatozoa, they pass into the vas deferens ; the spermatogonia again fill the apical region and the cycle is repeated.

II. Spermatogenesis.

1. *Maturation.*

The chief feature of interest in the history of the chromatin lies in the fact that the first maturation division separates univalent chromosomes and is therefore reducing.

This can be demonstrated by following the changes in the chromosomes from the synapsis stage through the first maturation division. In the anaphase of the last spermatogonic division the chromatin threads lie massed together near the center of the cell so as to be almost indistinguishable from each other. They gradually spread apart and are seen to be for the most part V-shaped (Fig. 2 *a*). There follows an elongation of the threads, and during this process the granules of which they are composed divide into two, so that each chromosome becomes longitudinally split (Fig. 2 *b*). Of the entire number of chromosomes present it is difficult to be certain, owing to the fact that they overlie each other so closely. The number, however, is certainly less than that present in the spermatogonia and not greater than sixteen. The reduction in the number of the chromosomes apparently takes place, therefore, at this stage, and the V-shape so prevalent is due to the approximation of two of the spermatogonic chromosomes to form a bivalent one. The threads become more and more attenuated, and finally by anastomosis are transformed into the nuclear reticulum of the resting spermatocyte. The fact that the chromosomes remain distinct until just before the formation of the nuclear membrane points to a maintenance of their individuality in the resting cell. In preparing for the first maturation division, the meshes of the nuclear network become coarser, the granules

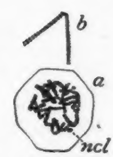

Fig. 2. — *a*, cell in the synapsis stage. *b*, bivalent chromosome at a later period of the synapsis, showing the longitudinal splitting of the chromatin granules ; *ncl*, nucleolus.

more distinct and aggregated into separate threads joined together by linin. The manner of their origin again lends support to the view concerning their individuality in the resting cell. By a gradual process of condensation sixteen compact masses of chromatin are produced. These sixteen masses are of various forms. Some are dumb-bell-shaped, two spheres of chromatin joined together by linin; some are crescent-shaped, and still others are more or less complete rings (Fig. 3). The different forms may occur in the same nucleus, but apparently without constancy in the ratio of relative frequency of occurrence.

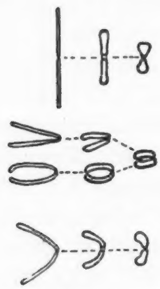

FIG. 3.—Mode of formation of the bivalent spermatocytic chromosomes (diagrammatic).

Two main types may be distinguished among the chromosomes according to their structure and mode of origin; *i.e.*, (1) those in which the bivalent chromosome consists of two univalent chromosomes lying end to end, as in those having the dumb-bell shape; and (2) those in which the univalent chromosomes lie side by side, as in those arising through a ring or narrow V-shape. A form intermediate between these is represented by those having a crescent shape. The different types and their probable mode of origin are shown in the diagram (Fig. 3).

In the equatorial plate of the first maturation division the two forms may again be seen. In sections stained with iron hæmatoxylin and strongly decolorized a longitudinal split is distinguishable in the chromosomes. In the dumb-bell-shaped chromosomes this lies parallel to the long axis of the spindle, but in the others more or less oblique to it, or at right angles to it (Fig. 4). In the spermatogonic divisions, on the contrary, as is shown in preparations similarly treated, the longitudinal split lies transversely to the long axis of the spindle (Fig. 5). Karyokinesis separates originally distinct chromosomes, and the first maturation division is therefore reducing. In many cases the chromosomes can be seen to be composed of a

FIG. 4.—Equatorial plate of the first spermatocytic division. *ncl*, nucleolus.

double row of four granules. After division the halves consist of a double row of two granules, or four in all, and thus simulate tetrads.

The true nature of the second maturation division, whether equational or reductional, is difficult to decide, because the length and the breadth of the chromosomes are approximately equal. Since most writers on the maturation of the germ cells in the arthropods agree in ascribing to them both methods of division (equation and reduction), it is probable that since the first division is reducing, the second is equational in Oniscus.

Fig. 5.— Equatorial plate of a spermatogonic division.

These results do not agree with those obtained by Rückert [1] and vom Rath [2] in the ovogenesis of the copepods. The case of Cyclops as described by Rückert is particularly clear. According to his observations the first maturation division is equational, the second reducing. If Rückert's interpretation of the method of reduction in Cyclops be correct, and my own concerning reduction in Oniscus be equally so, it becomes clear that the cell generation in which the true reduction takes place need not be the same for all members of a given class of animals.

Fig. 6.— Anterior portion of mature sperm colony (less highly magnified). *fl.*, flagellum; *pn.r.*, prenuclear region; *n.r.*, nuclear region; *f.r.*, region of cytoplasmic fibres.

2. *Metamorphosis of the Spermatids.*

The transformation of the spermatids of the isopods has already been described by Gilson [3] in his comprehensive work on the

[1] Rückert, J. Die Chromatinreduktion der Chromosomenzahl im Entwicklungsgang der Organismen, *Merk. u. Bon. Erg.*, Bd. iii, 1893.

Id. Zur Eireifung bei Copepoden, *Merk. u. Bon. Erg.*, Anat. Heft, 1894.

[2] Vom Rath, O. Neue Beiträge zur Frage der Chromatinreduktion in der Samen- und Eireife, *A. M. A.*, 46, 1895.

[3] Gilson G. Spermatogénèse chez les Arthropodes, *La Cellule*, 1884 and 1886, tomes i and ii.

spermatogenesis of the arthropods. In some respects my observations agree with his; in others they differ.

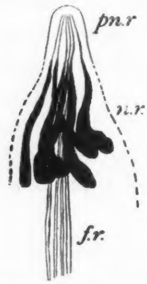

FIG. 7. — Longitudinal section of the anterior portion of an immature sperm colony. *pn.r.*, prenuclear region; *n.r.*, nuclear region; *f.r.*, region of cytoplasmic fibres.

The nuclei of the spermatids in Oniscus undergo a gradual elongation and condensation. During this process the cell walls between adjacent spermatids disappear and groups of nuclei are formed lying in a common plasma. Within the latter arise bundles of fibres of great length. Gilson in his Fig. 320 shows a direct continuity of these cytoplasmic fibrils with the elongated nuclei. That such a connection actually exists I have been unable to convince myself. In addition to the bundle of fibres there are single fibres of greater delicacy which are continuous with the nuclei. The appearance of the mature sperm colony may be seen from Fig. 6. Figs. 7 and 8 represent longitudinal and transverse sections of immature colonies. With Wilcox's double stain of saffranin and malachite green the cytoplasmic fibres stain green and are thus sharply differentiated from the nuclei, which stain red. In cross-section the nuclei are seen as a circle of red dots surrounding a group of green dots, the cytoplasmic fibrils. In examining a series of sections from the nuclear region towards the flagellum, the group of green dots in the center eventually ceases to be visible, and the surrounding red dots gradually merge into converging green fibres of great delicacy (Figs. 7 and 8). The evidence at my disposal admits of two interpretations, — either the long bundle of cytoplasmic fibres stops abruptly before the anterior end of the bundle is reached, and they thus have no connection with the nuclei, or the connection is of such a character as to escape observation. Since the structures concerned are extremely minute and delicate, the latter might easily be the case.

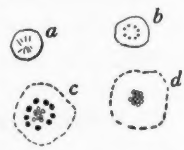

FIG. 8. — Cross-section of immature sperm colony. *a*, prenuclear region; *b* and *c*, nuclear region; *d*, region of cytoplasmic fibres.

III. Summary.

The main results of this study may be briefly summarized as follows:

1. The spermatogonic chromosomes are joined together in pairs in the synapsis to form sixteen bivalent chromosomes.

2. A longitudinal splitting of the thread takes place at this stage.

3. The distinctness maintained by the chromosomes up to the formation of the nuclear network of the resting spermatocyte and the manner of origin of the spermatocytic chromosomes from it lends support to the theory of their individuality in the resting nucleus.

4. In the structure and mode of origin of the bivalent chromosomes two main types may be distinguished: (*a*) the component chromosomes lie end to end, or (*b*) they lie side by side.

5. Inasmuch as univalent chromosomes are separated, the first maturation division is reducing.

6. Sphere substance (idiozome) is not observable, except for a short time during the prophases of the first spermatocyte.

7. The nucleolus of the spermatogonia disappears shortly after dissolution of the nuclear membrane, while that of the spermatocytes, first discovered in the synapsis, persists throughout the divisions.

8. The spermatids become associated in groups to form colonies of nuclei lying in a common plasma.

9. Within the latter arise bundles of fibres of great length, whose connection with the nuclei could not be demonstrated,[1] as well as single fibres of greater delicacy which are continuous with the nuclei.

10. The mature sperm colony consists of a variable number of filamentous nuclei contained, together with the bundle of cytoplasmic fibres, in a tenuous sheath which is flagellate at its anterior extremity.

[1] If such a connection is actual, it is slight and occurs very late.

I wish to express here sincere gratitude to my instructors, Dr. E. G. Conklin and Dr. Thomas H. Montgomery, Jr., for the valuable advice which has aided me in bringing this work to a successful completion.

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ON THE FORMATION OF SPECIFIC ANTI-BODIES IN THE BLOOD, FOLLOWING UPON TREATMENT WITH THE SERA OF DIFFERENT ANIMALS.

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DURING the thirteen years which have elapsed since I demonstrated the existence of bactericidal properties in the blood, pericardial and pleuritic fluids, a great deal has been discovered relating to other properties of the blood. The experiments referred to directly stimulated the researches which led to the discovery of the presence of anti-toxic, agglutinative, hæmolytic, and cellulicidal properties in blood serum. We have, moreover, learnt of the existence of a number of bodies which neutralize the action of these various substances.

More recently specific bodies or precipitins have been seen to occur in the serum of animals treated with the products of certain bacteria, with various kinds of milk, with peptone, egg albumin, and different kinds of blood.

Kraus (**'97**) was the first to demonstrate the existence of specific precipitins in the blood serum of animals immunified against cholera, typhoid, and plague. His results were subsequently confirmed by Nicolle and Marmorek. In these experiments the various anti-sera were added to clear culture-filtrates of the particular bacterium, and a precipitum was seen to occur in the filtrates of those cultures only to which the homologous anti-serum was added.

Bordet first demonstrated the existence of specific anti-bodies for milk. He treated animals with milk. After a time it was seen that their serum when added to a milk dilution brought about a precipitation. A precipitum was formed only when the anti-serum was added to the particular milk against which

the animal had been immunified. These results have been confirmed by Wassermann and Schütze, and demonstrate that there are essential differences in the composition of the albuminous molecule in the milks of man, cattle, and goat.

Myers demonstrated the existence of precipitins in the blood of animals treated with peptone, the precipitins acting only upon peptone.

The credit of having discovered the existence of specific precipitins in the bodies of animals treated with blood belongs to Tchistovitch. He inoculated animals with eel serum, which is toxic, and noticed that an anti-toxin made its appearance in the serum of the treated animals, but in addition their serum acquired the property of producing a precipitation when added to eel serum, whereas it did not act on other sera. A specific anti-body was also produced in rabbits treated with horse serum. Bordet demonstrated the existence of specific precipitins in rabbits which had been treated with fowl's blood. The anti-serum of these rabbits also produced a slight reaction in pigeon blood, showing that the bloods of the fowl and pigeon are of a somewhat similar composition. Nolf separated the corpuscles from the serum and treated two sets of animals with the separated blood ingredients. He found that only the serum-treated animals yielded the specific precipitin. He treated the serum with magnesium sulphate, thus removing the globulin. Animals were treated with globulin and albumin solutions derived from the serum, and it was found that precipitins were formed only in the serum of animals treated with globulin solutions.

Myers treated rabbits with fowl's egg albumin, as also with serum globulin of the sheep and bullock. He also observed the formation of specific precipitins in the serum of the treated animals, although a slight reaction took place on adding the anti-serum for sheep globulin to that for ox globulin and *vice versa*. Uhlenhuth also treated rabbits with egg albumin, and found that the anti-serum gave a reaction with 1 : 100,000 dilutions of egg albumin, whereas the most delicate chemical tests only gave a reaction with dilutions of 1 : 1000. He made the interesting observations that the precipitin appeared in the

serum of a rabbit which had been fed for twenty-four days with white of egg.

Leclainche and Vallée treated animals with albuminous urine and found that the serum of the treated animals contained a precipitin which acted upon the albuminous human urine with which they had been treated but not upon albuminous urine from the cow and horse.

Uhlenhuth treated rabbits with human blood and that of the ox, and observed the formation of specific precipitins in their serum which was tested on nineteen bloods derived from different animals. He obtained a reaction with a solution made from human blood which had been dried one month. Wassermann and Schütze made similar observations, testing twenty-three kinds of blood. Stern, who also experimented along these lines, found that the blood of three species of monkey gave a slight reaction with the serum of rabbits treated with human blood. In addition to other observations of a confirmatory character Mertens has found that the blood of a young rabbit born of a human serum-treated mother also contained the specific precipitin in its blood. The last observations which I shall mention are those of Dieudonné, and of Zuelzer, whose results are merely confirmatory in character. The majority of the publications referred to have appeared since I began my researches in January.[1]

I have injected rabbits intraperitoneally with the serum of man, the ox, sheep, horse, dog, and cat, and have been able to observe the formation of anti-bodies in the sera of all the rabbits excepting those treated with cat serum. The anti-sera have been tried on forty-five kinds of blood.[2]

The serum of rabbits treated with dog serum, added to all these bloods, gave a negative reaction throughout, excepting in the case of the dog. The tested dog blood was dried and dissolved in salt solution or used in the form of diluted fluid

[1] Full details of these experiments will appear in the forthcoming number of the *Journal of Hygiene*, vol. i (July 1), No. 3.

[2] Since the above was written, over one hundred and forty bloods have been tested—with uniform results. Fully realizing the interest of these tests from the point of view of zoölogical classification, the study is being pursued on an extensive scale.

serum. Whereas a marked and almost immediate precipitation occurred on the addition of the specific anti-serum to dog's blood, all the other blood solutions remained perfectly clear.

The serum of rabbits treated with sheep serum only produced a marked precipitum with sheep serum or blood solution. All the other sera and bloods remained perfectly clear, excepting those of the axis deer, gazelle and ox, in which a slight reaction took place, and those of the squirrel and swan, in which there was very slight clouding.

The serum of rabbits treated with ox serum only produced a marked precipitation in ox-serum dilutions, or dried ox-blood solutions. All the other bloods gave a negative reaction, a slight clouding only being produced in blood solutions of the sheep, gnu, axis deer, and gazelle, a slight opalescence appearing with that of the squirrel and swan.

The serum of rabbits treated with horse serum only produced precipitation in dilutions of horse's blood or serum, not even a clouding in any of the other bloods noted.

The serum of the rabbits treated with human blood, serum, and pleuritic exudation, only produced a marked precipitation in human blood solutions, etc. The blood of the four monkeys gave a slight but distinct reaction. A very faint clouding at times appeared in the solutions of the bloods of the horse, ox, and sheep, whereas all the other bloods remained perfectly clear. The test gave positive results when made with diluted human serum, pleuritic exudation, both fresh and putrid, blood and serum which had been dried on filter-paper and on glass plates, *with blood which had undergone putrefaction for two months*, with the blood of several persons who had cut themselves (blood collected on filter-paper), and with the serum from a blister following a burn on the hand and pressure on the foot. Both nasal and lachrymal secretion gave a slight but decided reaction. A faint clouding was produced in normal urine. That the precipitum formed in putrid blood dilution was specific was proved by adding the anti-sera of rabbits treated with ox, sheep, and dog serum to the blood dilution, no reaction resulting.

The tests made with dried blood, whether dried on glass or filter-paper, gave perfect reactions, as did also 1:100 dilutions kept for two weeks in test-tubes in the laboratory. Although chloroform had been dropped into the bottom of these tubes, molds occasionally developed upon the surface of the serum; but this seemed in no way to interfere with the specific reaction. Strips of filter-paper upon which both sheep and ox blood had been allowed to dry were placed under different conditions. Some were kept for two months at 37° C. in the dark; others at room temperature in the dark, and in diffused light for the same period; others again were exposed for eight days to the action of sunlight in a window. All of these samples gave apparently just as good reactions as fresh bloods, though of course our method cannot as yet be strictly considered to be quantitative. The body in the serum which is acted upon by the anti-serum, and the specific body in anti-serum, seem to be about equally resistant. Anti-serum dried for forty-two days on filter-paper and then dissolved in salt solution was found to give a perfectly characteristic reaction when added to its homologous (ox) serum, the latter diluted (1:100) as usual; it did not, however, produce a reaction in dilutions of other bloods. Dried normal sera exposed for half an hour to a temperature of 100° C. still gave a clear reaction, as did also 1:100 dilutions exposed for half an hour to 55°. As I first showed, the bactericidal properties of blood are destroyed at the latter temperature. Dilutions of blood exposed to a temperature of 100° gave no reaction.

The first rabbit in the series treated by horse-serum injections received old anti-toxic serum which had been kept at room temperature in the laboratory for *two years and seven months*. We are indebted to Dr. Louis Cobbett for this serum. The serum, to which trikresol had been added, had been kept in a corked bottle, exposed to diffused light, the temperature of the room being very high during the summer months. The first and second rabbits of the series treated with human pleuritic exudation, etc., received only one and two injections respectively of fresh serum, being treated for the rest of the time with pleuritic effusion which had been kept at room temperature for

five to six months. The pleuritic fluid had been preserved in a corked bottle with chloroform. These observations seem to me to possess a particular interest.

It seemed of interest, from a medico-legal standpoint, to determine whether or no a *mixture* of several kinds of blood would prevent the detection of one of the bloods in the mixture; the presence of another blood might inhibit the action of the anti-serum. To determine this question 1 : 100 dilutions of two to six kinds of blood were mixed together in equal proportions and tested with *positive results.*

Conclusions.

1. The investigations we have made confirm and extend the observations of others with regard to the formation of specific precipitins in the blood serum of animals treated with various sera.

2. These precipitins are specific, although they may produce a slight reaction with the sera of allied animals.

3. The substance in serum which brings about the formation of a precipitin, as also the precipitin itself, are remarkably stable.

4. The new test can be successfully applied to a blood which has been mixed with that of several animals.

5. We have in this test the most delicate means hitherto discovered of detecting and differentiating bloods, and consequently we may hope that it will be put to forensic use.

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THE COLORS OF THE CRAYFISH.

W. J. KENT.

SOME time has been devoted during the past year to a study of the influence of environment upon the colors of the crayfish. The work has been confined in a large part to the species *Cambarus immunis*.

It was first noticed, while studying the habits of crayfish by observations in field work, that the color of *immunis* in nearly all cases closely resembled the color of the environment. In one small pond of water, where the soil at the bottom was a blue clay, the crayfish were all blue in color. In another pond with a black, muddy bottom they were all black, and in still other places of different colors. But in nearly all cases they were of the same color as the environment.

One exception to this was found with those which were red. These were confined entirely to the shallow water in the small streams, and the color was not always similar to the color of the environment. The crayfish in all colors except red were found almost entirely in the ponds with deeper water and muddy bottoms. But it was discovered later that this red color in crayfish may be caused by exposure to sunlight. This was first observed while making a microscopic study of the pigment, to which most of the color of the crayfish is due. This pigment when removed from the crayfish and exposed to the sunlight turned red in a short time. The same result occurred when all effects of heat were excluded by using diffused light and an alum bath.

The influence of sunlight upon the color of living crayfish was studied further by experimenting in the laboratory. Crayfish of various colors were kept in an aquarium exposed to the light. This is a difficult experiment to carry out. Crayfish which live in deeper water become strongly photopathic and can endure only very weak light. It was necessary at first to

place the aquarium with the crayfish in diffused light and to allow them to become accustomed by degrees to changed conditions.

Some very good results were obtained in these experiments. Crayfish in black, blue, and green colors were changed to brown and red under the influence of light. These color changes, however, were very slow. Several months were required to produce distinct changes.

Other experiments were made in the laboratory upon the influence of environment on the color of the crayfish. A number were taken from different places where they were of various colors and kept for some time in an aquarium. This aquarium tank was made of zinc and was partly covered to exclude the light. In some cases very distinct color changes occurred. This was especially true of those which were red and black. Out of a large number of crayfish of different colors which were kept in this way for several months, nearly all were changed to the same gray color of the zinc aquarium.

An excellent illustration of color changes is furnished by another species, *Cambarus diogenes*. These may be found in any of the smaller streams. In the early spring they vary much in color, but later in the year nearly all are red. The explanation here lies in the habits of this species. They burrow during winter and come out in the spring with more or less of the color of the soil. These colors are gradually turned to red in the open sunlight. There has been no opportunity for observations upon other burrowing crayfish, but what is true of *diogenes* is no doubt true of other species which burrow in winter.

Some little time was also spent in studying color changes in the young crayfish. This study was made during the months of April and May of the present year, and was confined to one species, *immunis*. The young of *immunis* are at first red. This red color, however, is not apparent to the unaided eye. The pigment layer of a young crayfish consists of a number of large chromatophores which lie directly below the chitinous integument. These color bodies are somewhat scattered, and the little color they give is scarcely noticeable in comparison

with the colors of some of the internal organs, which can also be seen. The color of the young crayfish should be studied with the microscope. The integument of the young crayfish is perfectly transparent, and with a microscope any changes in color in the chromatophores is easily observed.

A series of observations was made upon the young crayfish in one pond where the old were black and in another pond where the old were blue. In this pond where the old crayfish were black the young were at first red and gradually changed to black. This change of color required about two months' time. In crayfish one or two weeks old only a very few of the chromatophores showed any change in color, while in crayfish one month old possibly one-half of them would be changed in color, and in those from two to three months old the process of color change was nearly always complete. The integument remains transparent up to this age, so that all stages in color changes were readily seen.

In the second pond where the old crayfish were blue the young, which were red at first, changed to blue, this change requiring about the same length of time. In other places where the old crayfish were red the young crayfish underwent no change in color. They were red at first and remained red in color. In this work the young crayfish of different ages were brought into the laboratory and examined. The color changes were such as occur among crayfish in their natural environment and under ordinary conditions. No attempt was made to keep them in the laboratory for the purpose of experiments.

From these observations it will be seen that the colors of crayfish are due to two causes. The sunlight produces the red color, though this same color may be caused by the environment. All colors excepting red are due to the influence of environment. In all cases these colors serve as a protection against enemies.

The greater part of this work has been confined to one species, *Cambarus immunis*, although some work has been done on three other species, *propinquus*, *bartonii*, and *diogenes*. But there seems to be no reason why similar changes in color should not occur among all other species.

A word should be said here against too hasty conclusions on this subject of colors. Many species of crayfish are migratory in their habits. This is especially true of those living in running water. The changes in color require some weeks or possibly months of time. For these reasons the color of crayfish seen in the small streams may not be at all like the color of the environment. The best results will be obtained from a study of the crayfish in the small ponds of water where migrations cannot occur.

NOTES AND LITERATURE.

GENERAL BIOLOGY.

Arnold's Sea Beach at Ebb Tide.[1] — This is the type of book which one wishes had been written years ago. Every one will recall his struggles when he first began seashore collecting; the vain attempts to identify the specimens found and in some cases even to ascertain the relationship of certain forms. Such a volume as this would have lightened the labors and have given additional pleasure to a trip to the shore. Although late in coming, it is none the less welcome and will doubtless be of great value to many beginners. The tendency of the past dozen years has been to stand in morphological and physiological lines, and the systematic side of biology has been too much neglected.

This volume simplifies many of the collector's difficulties, for with simple descriptions and characteristic figures it enables one to recognize a large number of the animals and plants found on the American coasts from Mt. Desert to Florida ; from Puget Sound to San Diego. It begins with hints on collecting and preserving specimens and then takes up, in systematic order, the algæ, sponges, cœlenterates, worms, molluscoids, echinoderms, arthropods, mollusks, and tunicates, describing and usually figuring the more common species. Each of these groups has a section or chapter devoted to it, and the descriptions are prefaced by an outline of the morphology, life-history, and economic relations of the group.

In looking more closely at the text one notices certain blemishes which are almost unavoidable in a work of such large scope and which will doubtless disappear in future editions, for future editions there will certainly be. Thus in the chapter on collecting there should be directions for killing the animals properly, and there certainly should be some hints as to the use of formal as a preserving fluid. Again, there is noticeable a lack of symmetry in terminology. Thus among the decapods we find that Gelasimus has given way to

[1] Arnold, Augusta Foote. *The Sea Beach at Ebb Tide*, a guide to the study of the seaweeds and the lower forms of animal life found between tide marks, with more than 600 illustrations. New York, The Century Company, 1901. x + 490 pp.

Uca, while Homarus remains ; in the mollusk the latest vagaries of the systematist are introduced, while in the worms a more conservative course has been adopted. Here and there errors occur. Thus the nemertines are regarded as a class of Plathelminthes, and (p. 164) the flatworms are stated to lack an anus. Under the Gephyræa, *Sipunculus nudus* is included as an American form, while Echiurus and Thalassema are ignored. Yet these are minor blemishes, and the work will prove most useful not only to the casual visitor to the shore but to the more experienced naturalist as well.

K.

PHYSIOLOGY.

Reactions of Hydra to an Electric Current. — Pearl[1] has observed that *Hydra viridis*, when attached by the foot and placed in the path of a constant current of weak intensity, brings the long axis of the body in line with the current, the oral end being toward the anode. This orientation is accomplished by a contraction on the anode side of the body. When the animal is not attached by the foot, the anode side still remains the side of contraction, even though the oral end may be turned toward the cathode. In addition to orientation, the current may call forth general contractions. Separate pieces of the hydra react in much the same way as whole animals. Buds and parent animals are independent in their reactions, the buds showing essentially the same reactions as adults.

P.

Evolution of Pigment. — The interest which biologists have shown in the chemical activities of protoplasm has evinced itself in the study of pigment as a protoplasmic product. Bohn's[2] contribution to this subject is a timely *résumé* of some of the more important recent results. The pigments are classified as hydrocarbons, derivatives of chromatin, and derivatives of the aromatic series. The vegetable pigments are described under the heads of chromogenic bacteria and chloroleucites. The occurrence, migration, and transformation of animal pigments occupies much of the volume. The author believes that in a given cell there may be a struggle between

[1] Pearl, R. The Reactions of Hydra to the Constant Current, *Amer. Journ. Physiol.*, vol. v (1901), pp. 301–320.

[2] Bohn, G. *L'Évolution du Pigment.* Paris, Carré et Naud, 1901. 96 pp.

the various classes of pigment granules, resulting in a selection of the more favored kind. In consequence of this a harmony of color would prevail, first locally and finally throughout the organism.

P.

Excretion in Annelids. — The elimination of waste products from the bodies of annelids, particularly earthworms, has been fully studied by Willem and Minne.[1] In Lumbricus reserve products in the form of fat and of glycogen occur, the former in the ciliated cells of the intestinal epithelium, the latter in the peritoneal cells. True waste products are found in the same animal as guanine in the chloragogic cells and nephridial tubules, as uric acid in the peritoneal cells and similar elements found between the fibres of the body musculature, and as cholesterine probably in all tissues. The chloragogic cells produce guanine with more or less regularity. This is periodically discharged from these cells into the cœlomic fluid, where in common with other particles it is engulfed by the free cœlomic cells. The cœlomic cells when charged with the products of excretion make their way through the intestinal epithelium and are finally discharged into the digestive cavity The nephridial walls excrete soluble materials exclusively. Only a small amount of cœlomic fluid passes through the nephridial canal. This fluid is kept in motion by the cilia of the canal and the waste products are thus discharged.

Similar studies were made on Nereis, Nephelis, and Clepsine, and the following general conclusion drawn. In all the annelids studied the cells that line those parts of the cœlom particularly connected with the circulatory system are of service in purifying the blood. They accumulate in their protoplasm various excretory products, in some annelids one, in others another. Thus far the following substances have been identified : uric acid, guanine, sodic urate, and a substance like chitine. Many annelids show a tendency toward the obliteration of the nephrostomes, and this is accompanied by a change in the way in which the solid excreta are discharged. Cast out freely in those worms with large nephridial funnels, these products in worms with restricted nephridia are accumulated and disintegrated in the phagocytic organs and thus prepared for discharge.

P.

[1] Willem, V., et Minne, A. Recherches sur l'Excrétion chez quelques Annélides, *Mém. l'Acad. roy. de Belgique*, tome lviii (1900), pp. 1-73, Pls. I-IV.

ZOÖLOGY.

Coccidæ Americanæ. — The work bearing this title consists of a series of specimens neatly arranged in a portfolio, with sufficient printed matter to explain where descriptions of them will be found, and what plants they infest. The part just issued by Messrs. Quaintance and Scott of Georgia is the second of the series, the first having been prepared in Florida by Messrs. Rolfs and Quaintance. Each part contains twenty species, most of them of economic importance, and all correctly named; so it will readily appear that the work is a very useful one for experiment-station workers and others who have to determine Coccidæ.

The only adverse criticism one can pass upon the part under review is that the synonymy given for the species is in many cases wrong; in several instances the alleged synonyms are not even congeneric. This results from the uncritical acceptance of the work of other authors, and the present writer has erred too often in a similar way to be very severe on the subject.

T. D. A. C.

Coccidæ Stanfordianæ. — It is a pleasure to receive from Stanford University four excellent papers on Coccidæ, written by the students of that institution. These papers are bound together as a contribution from the Hopkins Seaside Laboratory, and are as follows: (1) "Notes on Cerococcus," by Rose W. Patterson; (2) "New and Little-Known California Coccidæ," by S. I. Kuwana; (3) "The Redwood Mealy-Bug," by George A. Coleman; (4) "The San José Scale in Japan," by S. I. Kuwana. These papers are full of valuable information, and are accompanied by admirable plates. Miss Patterson describes and figures the three species of Cerococcus which occur on the Pacific slope (*C. quercus* Comst., *C. ehrhorni* Ckll., and *C. corticis* Twns. and Ckll.), giving many new facts. She is evidently unaware that a fourth species (*C. ficoides* Green) occurs in India. Mr. Kuwana gives for the first time an account of the transformations of *Pseudolecanium tokionis*, including the description of the adult male, which will be greatly appreciated by coccidologists. He also describes three new species in the genera Eriococcus, Ripersia, and Lecanium. The *Ripersia festucæ* is a peculiar creature, having the female elongated, much like the male larva of ordinary Ripersia. It might be referred to Pergandiella were the antennæ 8-jointed; possibly the discovery of the male will indicate its closer affinity with Fonscolombia.

Mr. Coleman describes the redwood mealy-bug as *Dactylopius sequoiæ*, but, as Mr. Ehrhorn remarked to me, it is rather a Phenacoccus, notwithstanding the 8-jointed antennæ. It has certainly no affinity with the two species of Dactylopius it is said to most resemble. The description is very full, and includes all stages. T. D. A. C.

Fishes of Japan. — In the *Proceedings of the United States National Museum* (Vol. XXIII, pp. 739–769) Jordan and Snyder record the species of fishes collected in Japan by Mr. Pierre L. Jouy. These are eighty-three in number, six of them being new to science. These are *Leuciscus jouyi*, *Apogon unicolor*, *Pomacentrus rathbuni*, *Aboma tsushimæ*, *Chasmias misakius*, and *Watasea sivicola*. Chasmias is a new genus of gobies near Gillichthys, and Watasea a new brotulid near Neobythites. The new species are figured. I may here note that the name Chasmias is preoccupied by Chasmias Ashmead, a genus of Ichneumons, published a little earlier in the same proceedings. For the genus of fishes, Chasmichthys Jordan and Snyder may be substituted.

In the same paper is given an identification of the species of Japanese fishes collected by Dr. Thunberg and loosely described by Houttuyn in 1782. The adoption of Houttuyn's names necessitates several changes in nomenclature, among others the use of the name *Scomber japonicus* in place of *Scomber colias*, for the common chub mackerel.

Jordan and Snyder have begun a series of monographic reviews of families of Japanese fishes. The first now published (*Proceedings of the United States National Museum*, Vol. XXIII, pp. 725–734) includes the lancelets and lampreys, the second, the eels. In the first of these papers the new species are *Branchiostoma nakagawæ*, *Myxine garmani*, and *Lampetra mitsukurii*, the latter being a manuscript name of Dr. Hatta.

In the review of the eels, fifty species are described, of which nineteen are new, all of these and some of the others being figured. The new genera are Xyrias, near Cirrhimuræna, but without cirri, and Æmasia near Gymnothorax, but with the mouth bristling with large canines. D. S. J.

Fowler on Fishes in the Philadelphia Academy. — In the *Proceedings of the Academy of Natural Sciences* at Philadelphia (Vol. LIII) Mr. Henry W. Fowler gives a number of interesting notes on fishes. The types of new species of selachians in the academy museum are

redescribed with special reference to their anatomy. Among these are numerous types of species named in Bonaparte's *Fauna Italica*, purchased for the academy by Mr. T. B. Wilson.

The fishes recently noted by Mr. Fowler as from the Caroline Islands came from a coral reef called Caroline, or Thornton, Island, remote from the Carolines, and near Samoa.

From Mazatlan, Mexico, Mr. Fowler describes a new genus of Hemiramphidæ with the form of Fodiator and the long beak of Hemiramphus. The species is called *Hemiexocœtus caudimaculatus*. It is midway between the halfbeaks and the flying fishes.

The generic name Odontostomus, applied by Cocco to a deep-sea fish, is preoccupied in mollusks. In place of Odontostomus, Mr. Fowler proposes the new name Evermannella. The family, now composed of the two genera, Evermannella and Omosudis, becomes Evermannellidæ.

D. S. J.

Jordan and Snyder on New Fishes in the Museums of Japan. — In the *Journal of the College of Science of the Imperial University of Tokyo* (Vol. XV, Part II), Messrs. Jordan and Snyder have descriptions of nine new species of fishes in Japanese Museums of which no specimens are yet available except the original types.

These species are:

Acipenser kikuchii, from Sagami Bay.
Lepidopus aomori, from Aomori.
Tetrapturus mitsukurii, from Misaki and numerous other localities.
Tetrapturus mazara, from Misaki.
Bentenia æsticola, from Kashima.
Ebisus sagamius, from Misaki.
Reinhardtius matsuuræ, from Misaki.
Trachypterus ishikawæ, from off Tokyo.
Trachypterus ijimæ, from off Tokyo.

Of the two new genera, Bentenia is nearest Velifer and Pteraclis, and is distinguished by the anterior insertion of its dorsal and anal, each of which has one spine greatly enlarged.

Ebisus is a huge bass or jewfish, allied to Stereolepis but with the head unarmed and the teeth larger. It is locally known as Aburabozu, the "fat priest."

Dr. Mitsukuri has illustrated the paper by photographs of the type specimens, in so far as these are available.

D. S. J.

Check List of the Fishes of Japan. — In the series called *Annotationes Zoologicæ Japonenses* (Vol. III), published by the Zoölogical Society of Tokyo under the auspices of the Imperial University of Tokyo, Jordan and Snyder give a "Preliminary Check List of the Fishes of Japan." This catalogue is a neatly printed memoir of 159 pages.

It includes 686 species, exclusive of species from the Kuriles and Riu Kiu, mentioned in footnotes. The known localities in Japan are enumerated for each species, and the Japanese vernacular name of each is given. These vernacular names, corrected and largely compiled by Dr. C. Ishikawa, give the paper a special value to Japanese students.

The paper was in press before the authors planned their expedition to Japan in 1900. In this expedition upwards of 250 species were added to the list and a number of changes and corrections will be rendered necessary. The total number of species of fishes now known from the entire empire is between 1000 and 1100.

We may note that the new genus *Corusculus* (*berycoides*) is identical with the earlier Eteliscus, having the same type. The appearance in the text of this needless name was the result of accident.

The paper is "dedicated to Professor Kakichi Mitsukuri of the University of Tokyo in recognition of his work as a naturalist and of his character as a man." It is to be hoped that this paper, written in America and published in Japan, may help serve the purpose of bringing Japanese science and that of the nations called Occidental into closer touch with each other.

D. S. J.

Notes. — The spouting of the finback whale has been successfully observed by Henking (*Zool. Anzeiger*, Bd. XXIV, pp. 103–111, 1901) while off the Norwegian coast. The spout is not in any sense a jet of water, but is a cloud of water particles, as maintained first by Scoresby, and is driven out of the animal's nostrils by an operation not unlike a sneeze. The cloud usually has the outline of a reversed comma and Professor Henking's paper is noteworthy as containing the first accurate drawings of this outline.

The difficulty of ascertaining the exact limits of the ectoderm and the entoderm in the mouth cavity of vertebrates has been the chief obstacle in determining from which germ layer the hypophysis is derived. Zeleny (*Biological Bulletin*, Vol. II, pp. 267–281) has found that in turtles this organ is formed before the mouth breaks through and that it is derived from the ectoderm.

In a synopsis of the rice rats (Oryzomys) of the United States and Mexico, Merriam (*Proceedings of the Washington Academy of Sciences*, Vol. III, pp. 273–295) adds twenty-two new species and subspecies to the thirteen already known.

Phoronis pacifica, a new species described by H. B. Torrey (*Biological Bulletin*, Vol. II, pp. 283–288), is interesting as the first of this almost cosmopolitan genus to be taken on our west coast.

BOTANY.

Plant Life of Alabama.[1] — For nearly forty years the late Dr. Mohr gave close attention to the flora of his adopted home, Alabama; and the later years of his life were devoted to the preparation of a book embodying the results of his long study. He lived to see the last proof sheets corrected, but the date of its publication is a fortnight later than that of his death. A historical account of the botanical work done in Alabama, a detailed study of its physiography, geology, and meteorology, and a discussion of the general principles of plant distribution, lead to an analysis of the features marking the Alabama flora, which, more than any other North American work, exemplifies the trend of modern ecological study in a varied region; and the book closes with an annotated systematic catalogue of the spontaneous plants, including descriptions of new or critical species, a discussion of the relations of the flora to agriculture, and a list of plants known to be cultivated in the state. Considering Dr. Mohr's advanced age, it is remarkable that he should have adapted himself to the current trend of American botanists in regard to nomenclature, but in this, as in his grasp of the newer field problems in botany, he shows a plasticity far out of the ordinary run, and his work, which is of lasting value, is likely to produce nowhere the impression that a younger man, if possessed of his knowledge, could have done it better.

W. T.

Notes. — The varied and far-reaching character of the botanical work being done under the geological and natural history survey of Minnesota is shown by part 5 of the current series of *Minnesota*

[1] Mohr, Charles. Plant Life of Alabama, *Contr. U. S. Nat. Herb.*, vol. vi. 921 pp., with several plates. Washington, Government Printing Office, 1901.

Botanical Studies, bearing date July 20, which contains: A preliminary list of Minnesota Uredineæ, by E. M. Freeman, A new species of Alaria, by De Alton Saunders, A preliminary list of Minnesota Xylariaceæ, by F. K. Butters, A contribution to the knowledge of the flora of the Red River valley in Minnesota, by W. A. Wheeler, Observations on *Gigartina exasperata*, by H. B. Humphrey, Observations on the algæ of the St. Paul city water, by M. G. Fanning, Notes on some plants of Isle Royale, by W. A. Wheeler, Revegetation of Trestle Island, by D. Lange, Violet rusts of North America, by J. C. Arthur and E. W. D. Holway, and Observations on the embryogeny of Nelumbo, by H. L. Lyon. The number is unusually well illustrated.

Of interest to botanists, as well as ornithologists, is a pleasantly written account, by Dr. O. Widmann, of a visit to Audubon's birthplace, separately printed from *The Auk* of April.

Mr. Massee continues his redescriptions of Berkeley's types of fungi in No. 243 of the *Journal of the Linnean Society.*

Science of July 26 reprints from the London *Times* an article on the recent report of a committee appointed for the investigation of the botanical work carried on at Kew and South Kensington.

A biographic sketch of the late Prof. T. C. Porter, with portrait, appears in the July number of the *Bulletin of the Torrey Botanical Club.*

The flora of the Palouse region of Washington is the subject of a paper by Piper and Beattie, published in May by the Agricultural College of that state. It contains descriptions of all of the Spermatophytes and Pteridophytes known to grow wild within 35 kilometers of the town of Pullman, and is provided with keys to the families, genera, and species. In nomenclature, the Kew and Berlin rules have been followed.

A recent number of the *Gardeners' Chronicle* contains a figure, copied in the *Revue Horticole* of July 16, showing an Abyssinian landscape characterized by arboreous species of lobelia, which is as striking as the yucca, cactus, and other bizarre landscapes of arid regions on the American continent.

Mr. J. Medley Wood's *Natal Plants*, figuring and describing some of the more interesting constituents of a most interesting flora, has reached part 2 of the third volume.

The first part of Vol. V of the *Flora Capensis*, edited by Sir W. T. Thiselton-Dyer, extending from the Acanthaceæ to Clerodendron in the Verbenaceæ, has recently appeared from the press of Lovell Reeve & Co., of London, — unfortunately without indication of the date of issue.

An interesting essay on palms and their value to residents of tropical countries, by Professor Schröter of Zürich, constitutes the last *Neujahrsblatt of the Naturforschende Gesellschaft* of that city.

In connection with a monograph of garden beans recently published from the Missouri Botanical Garden, a paper by Professor Halsted on bean diseases and their remedies, constituting *Bulletin 151* of the New Jersey Agricultural Experiment Station, becomes of double interest. Like all of Professor Halsted's papers, it is well done.

PETROGRAPHY.

Origin of Corundum. — The interesting problem relative to the origin of corundum in basic rocks has been attacked by Pratt[1] through the study of slags. He finds that the separation of corundum from magmas is dependent upon the composition of the magma, upon the character of the oxides dissolved in it, and upon the quantity of alumina present.

When the magma is a calcium-sodium silicate, corundum separates only when the ratio of Al_2O_3 to the other bases exceeds 1 : 1, and the ratio of SiO_2 is less than 6. If Mg and Fe are present, no corundum will form unless there is more than enough Al_2O_3 present to unite with these bases.

When the magma is a magnesium silicate without excess of Mg, all the Al_2O_3 will separate. If Mg is in excess, some of the Al_2O_3 will unite with this, forming spinel, and the remainder will separate. When Cr_2O_3 is present and only a little Al_2O_3 and MgO, these unite with the Cr_2O_3, yielding chromite. No corundum is formed.

When alkalies or alkaline earths are present, the Al_2O_3 tends to unite with these in the formation of feldspars. There is, however, little tendency to the formation of Mg-Al silicates when the magma is a magnesium silicate.

[1] *Amer. Journ. Sci.* (1899), p. 277.

The Calculation of Rock Analyses. — Now that so much interest centers about the chemical composition of rock magmas and the representation of their composition in terms of molecular ratios, a recent paper by Kemp[1] on the methods of calculating rock analyses in these terms will be of great use to all students of rocks. In this paper the author shows how to transform percentages into molecular proportions, and from these how to calculate the mineral composition of any given rock. The most valuable portion of the article is a series of tables in which the "molecular proportions" of each of the rock-forming oxides is indicated for its corresponding "percentage" in rock analyses.

Weathering of Granites. — The conclusions drawn by Watson[2] from the results of an interesting study of the weathering of a number of granitic rocks of Georgia are as follows: Assuming that Fe_2O_3 has remained constant, (1) the amount of water in the weathered rocks increases rapidly as decomposition advances. At the same time there is a loss of SiO_2 and of all the metallic oxides except Al_2O_2, which in some cases shows a relative increase. (2) The loss of SiO_2 is not caused by solution of the quartz of the original rocks, but is the result of the decomposition of silicates. (3) CaO and Na_2O disappeared in larger quantities than MgO and K_2O. (4) The total loss of constituents varies between 7.68 % in weathered phases to 71.82 % in thoroughly decomposed forms.

Origin of Phenocrysts in Granites. — The same author[3] has also investigated these granites with respect to the origin of their phenocrysts. He describes in detail a large number of occurrences and concludes his study in these words: "The absence of (*a*) definite arrangement or orientation among the phenocrysts; (*b*) of phenocrysts from the border zones of the massif — gradation from an interior porphyritic facies peripherally into an even granular granite of coarse texture and the same mineral and chemical composition; (*c*) the further absence of evidence of magmatic resorption or corrosion of the phenocrysts; and (*d*) the presence of abundant inclusions of all the ground-mass constituents characterizing the generally tabular phenocrysts of the Georgia porphyritic granites, fully justify the conclusion that the phenocrysts in these rocks were formed *in place*, and are not intratelluric in origin."

[1] *School of Mines Quart.*, vol. xxii, p. 75.
[2] *Bull. Geol. Soc. Amer.*, vol. xii (1901), p. 93.
[3] *Journal of Geology*, vol. ix (1901), p. 97.

The granites are found in the Piedmont plateau region. They comprise even-grained and porphyritic varieties, and granite gneisses, all of which are plainly intrusive. Each variety is clearly described by the author, who also gives analyses of many types. Averages of these analyses give the following figures:

	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O
Normal granites	69.67	16.63	1.28	.55	2.16	4.73	4.71
Porphyritic granites	69.28	16.73	1.75	.72	2.13	4.33	4.59
Granite-gneisses	73.76	14.52	1.03	.29	1.14	4.16	4.63

The normal and porphyritic phases possess the same composition. The gneisses, however, are more acid than these, while their percentages of Al_2O_3, CaO, and MgO decrease.[1]

Gneisses of the Adirondacks. — The gneisses of a portion of the Adirondacks are briefly described by Cushing[2] in a report on the geology of Franklin County, New York. They comprise granite-gneisses with the composition of hornblende-granites, and pyroxene-gneisses. The latter consist of pyroxene (augite and hypersthene), plagioclase, orthoclase, some hornblende and quartz. Intermediate gneisses composed of hornblende and andesine, with augite and hypersthene as common accessory constituents, are also present in some localities. These are identical in their features with certain hornblende-gneisses derived from gabbros, but the author is inclined to separate them from the latter as of different age. Intrusive in these gneisses and in the Grenville series of sediments which are so well represented in the district are great dykes and masses of anorthosite, gabbro, granite, diabase, and syenite porphyries. The various types of most of these rocks have been described many times. The author adds new descriptions which serve to show that the types are quite uniform over large areas. The syenite grades into granite, both rocks being regarded as differentiates of one magma. The syenites are composed essentially of orthoclase and albite or oligoclase in microperthitic intergrowths, augite, hypersthene or bronzite and quartz. Hornblende is nearly always present to some extent. With the increase in this component the hypersthene diminishes. The rock varies rapidly in composition and structure. All the intrusions except the diabases and porphyries have been subjected to great pressure and have yielded gneisses.

[1] *Amer. Geologist*, xxvii (1901), p. 199.
[2] *18th Report State Geologist*, Albany, N. Y., 1900.

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